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THE QUARTERLY
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I. THE ILLUMINATED DISC OF THE MOON.

By Lieut.-Colonel A. W. Drayson, R.A., F.R.A.S.

In the examples which we have given relative to the pole star and the pointers, the reader's attention has been directed towards the northern portions of the heavens, and to those curves and straight lines affecting certain phenomena connected with the apparent motion of the celestial bodies. We will now call attention to the southern portion of the heavens, and refer to those laws which affect the apparent position of celestial objects near the Southern Meridian.

In order to comprehend the relative position of celestial objects as regards the equator of the earth, it is necessary to trace out on the sphere of the heavens an imaginary arch or curve which represents exactly in the heavens that curve which the equinoctial (that is the equator produced to the sphere of the heavens) actually occupies in the heavens.

To an observer situated at the North Pole the equinoctial would be a great circle in the heavens, exactly coincident with his horizon. To an observer in 45° north latitude the equinoctial would appear an arch in the heavens, 45° above his horizon directly south, and coincident with his horizon at the east and west points. To an observer at the equator the equinoctial would appear a straight line, cutting the east and west points of the horizon, and passing through the zenith.

The apparent curve or arch in the heavens formed by the equinoctial, as seen from latitude 45° north, can be traced out with great accuracy. The altitude of the equinoctial on the meridian is always equal to the co-latitude; thus the meridian altitude of the equinoctial for 45° north latitude will be 45°. Taking arcs of the equinoctial of 10°, we

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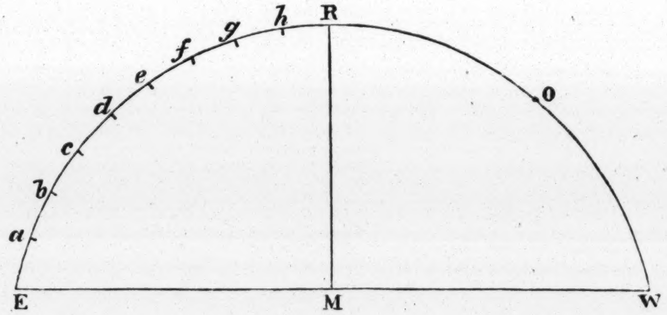
should have the following as the altitude of the points 10° distant from each other, viz.:—

7° 3′
14° 0′
20° 42′
27° 2′
32° 48′
37° 46′
41° 38′
44° 8′
45° 0′

Thus, in the following figure, let M R represent a portion of the meridian, E W the horizon, M the south point of the horizon, E the east and W the west points. The arc, E, *a*, *b*, *c*, R, is the equinoctial, being that quadrant between the east point on the horizon, and the meridian, *a*, *b*, *c*, &c., represent arcs of 10°.

FIG. 1.



The point *a* will be 7° 3′ above the horizon, *b* 14° above the horizon, *c* 20° 42′, and so on. In the same manner the curve from R to W may be traced out during the whole quadrant.

Let us suppose that there are three stars, *a*, *b*, *c*, situated on the equinoctial, and in the positions indicated by *a*, *b*, and *c*. Also that another star was situated at O, also on the equinoctial.

To an observer at the North Pole these four stars would appear on the horizon, and a straight line joining *a* and *c* would pass through *b*, and if produced would pass through the star O. To an observer at the equator, on the meridian, of which R M is a part, and so situated that R was in the zenith, the three stars, *a*, *b*, *c*, would also appear in the same straight line, and this straight line if produced would pass through O.

To an observer at 45° north latitude the line passing through *a*, *b*, and *c* would not be a straight line, or would not appear as a straight line. If the stars, *a* and *c*, be joined by a straight line, and this straight line were produced in the direction of and beyond the meridian, R M, this line would not pass through O. In order to pass through O this line must be curved and not straight, and no straight line joining *a* and *c* and produced would pass through the star O, if the observer were in 45° north latitude. Having examined these facts, we will now note how the same laws apply to the illuminated disc of the moon.

The moon shines and is visible to us in consequence of the light of the sun and because of the moon reflecting this light. The moon being a sphere, it follows that half the moon must at all times be illuminated by the sun. When the illuminated portion of the moon is turned directly towards the earth the moon is of course full; when this is the case the moon and the sun as seen from the earth are 180° apart.

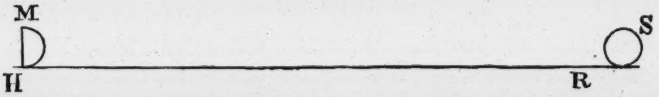
When the moon and the sun as seen from the earth are 90° apart the moon will appear half illuminated, the illuminated hemisphere visible to us being turned exactly towards the sun.

Let us take for illustration the following conditions:—The moon and the sun both on the equinoctial, the moon apparently half illuminated, the sun therefore 90° from the moon.

Under the above conditions, we will suppose an observer situated at the North Pole of the earth, and we will examine the appearance of the moon and sun as seen by him.

To an observer at the North Pole the equinoctial would coincide with the horizon; consequently, the moon and the sun would both appear on the horizon, and 90° apart. The line separating the dark part from the light part of the moon would appear at right angles to the horizon; consequently a line drawn at right angles to the line separating the light part from the dark part of the moon, and produced, would pass through the sun's centre. The appearance of the half moon and the sun to an observer at the North Pole would be, as shown in the sketch above (Fig. 2), where M represents the moon, S the sun, and the line H R the horizon.

Fig. 2.



The point, however, to which particular attention is directed is that the line drawn at right angles to the line of light and shade on the moon, and produced towards the sun, will pass exactly through the sun's centre. Such a line is H R.

The moon and the sun, as here shown, are 90° distant from each other, and the moon consequently is half illuminated.

We will now suppose exactly the same conditions to prevail as regards the sun and the moon's position in the heavens. They will still be supposed 90° distant from each other, and both situated on the equinoctial, but we will now examine the appearance of these two objects as seen by an observer on the equator.

We will suppose an observer to be so situated on the equator that his zenith is equidistant from the sun and the moon. The sun and the moon being 90° distant from each other, it follows that to this individual the moon would have an altitude of 45° above one part of the horizon (say the east) where the equinoctial cuts it; the sun therefore would be 45° above the west horizon. The line drawn at right angles to the line of light and shade on the moon would be directed past the zenith and towards the sun's centre.

From an examination of this and of the preceding demonstration, in which the appearance of the sun and moon is described as they would appear to an observer at the pole, it will be evident that the line drawn from the moon to the sun must coincide with the equinoctial, and that under the conditions named, viz., both the moon and the sun being on the equinoctial, the line of light and shade on the moon will always be at right angles to the equinoctial.

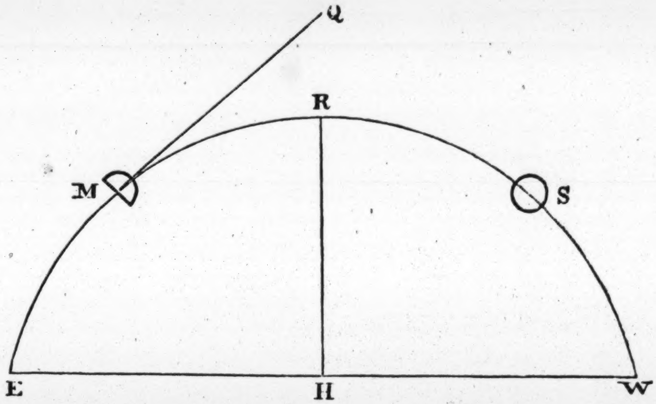
We will now consider the appearances presented by the sun and moon when seen by an observer in 45° north latitude, and under the conditions of these two celestial bodies being 90° apart, both on the equinoctial, and both equally distant from the meridian.

From the demonstration already given as regards the position of the equinoctial on the sphere of the heavens, we can at once place the sun and the moon in the positions they would occupy under the above conditions.

Thus, let E H W (Fig. 3) represent the horizon, H R that part of the meridian intercepted between the horizon and the equinoctial, E M R S W the position of the equinoctial on the sphere of the heavens, M the position of the moon

45° east of the meridian, S the position of the sun 45° west of the meridian.

FIG. 3.

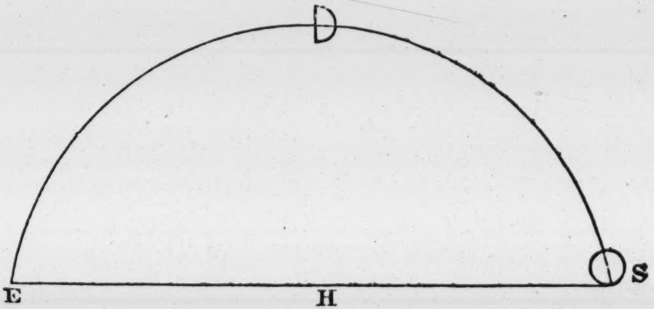


Under the above conditions the straight line of the moon will be at right angles to that part of the curved line formed by the equinoctial, on which the moon at the time is located. Thus the moon will appear tilted sideways as it were, as shown in this diagram, and the line of light and darkness on the moon will not appear at right angles to the horizon.

If we draw a line at right angles to the line of light and shade on the moon, and produce this line as a straight line past the meridian, H R, this line will not now pass through the sun's centre, but will be traced in the direction of M Q, and will pass considerably above the sun.

When the moon reaches the meridian, the sun, 90° from it, will be on the horizon and in the west. The moon will then appear in the position as regards the line of light and shade vertical, as shown in the following diagram (Fig. 4),

FIG. 4.



where, as before, H M is a part of the meridian, E H S the horizon, M the moon, S the sun. A line drawn at right angles to the line of light and shade on the moon will now, if produced, be a line parallel to the horizon, and will not be a line coincident with a straight line joining the sun and the moon.

In these two examples the right hand side of the moon has been given as the illuminated side; exactly the same laws will hold good when the left side of the moon is illuminated, the most marked effects being visible when the moon is 90° distant from the sun, and when the sun and moon are equally distant from the horizon, and the observer is at or near 45° latitude.

It may be difficult for those individuals who are not gifted with great powers of observation to perceive that the pointers sometimes point more directly towards the pole star than they do at other times. We believe, however, that this fact is one which merely requires attention to be directed to it, after which it will be perceived.

The phenomenon connected with the illuminated disc of the moon is one which does not require such careful observation as does that relative to the pole star and the pointers: very average observation will enable a person to note the facts to which we have called attention relative to the illuminated portion of the moon's disc that is turned towards the earth. Thus, if the reader either does not understand the demonstrations here given, or doubts their accuracy, he can examine the fact for himself, and if he select the suitable conditions, he can twice a month observe the phenomenon in the heavens. The best time to note the fact is when the moon is in either the first or the last quarter, and when consequently she is half illuminated. If the moon be illuminated on the west side, that is during the first quarter, the best time to observe the effect is at 3 P.M. If the moon be illuminated on the left or east side the best time will be 9 A.M. The winter time is better than the summer, because during winter the moon's light enables her to be better seen than during the summer.

The same geometrical laws of the sphere which cause the pointers to alter the direction in which they point relative to a fixed star, also cause the line of light and shade on the moon to appear sometimes not at right angles to the line joining the moon and the sun. It is a singular law, but it is one not without interesting results.

Singular as it may appear to some readers, yet it is a fact that not one individual out of one thousand to whom we have spoken on the subject has ever remarked that the pointers did not always appear to point to the pole star, and scarcely one person in a hundred has ever remarked that appearance of the moon when half illuminated which we have here called attention to, and of which we have given the geometrical cause.

Thus it may be said that, under certain conditions, straight lines in the heavens may appear like arcs of circles or ellipses, whilst arcs of circles appear like straight lines, and these changes are due to the relative position on earth of the observer, in spite of the fact that, compared to the alteration in position on earth of an observer, the distance of the fixed stars are infinite, and at a superficial glance it would seem that no change of position on earth could alter their apparent relative position as regards each other.

II. RAILWAY ACCIDENTS.

By FRED. CHAS. DANVERS, Assoc. Inst. C.E.

SO much attention has of late been given to the subject of railway accidents, and the best means of preventing them, and so important is it in the interest of the public generally, that a few pages of the "Quarterly Journal of Science" may, with advantage, be devoted to a consideration of how far all known and practicable means for the mitigation of the dangers of railway travelling have been adopted. In investigating this question we must refer briefly, in the first instance, to the early history of railway legislation, with a view to trace what steps have been taken by the Government for the protection of travellers, prior to enquiry as to what action has been taken by the railway companies themselves with the same object.

The earliest railway or tramway Act was passed in 1801, for the construction of a railway from Wandsworth to Croydon, for "the advantage of conveying coals, corn, and all goods and merchandise to and from the metropolis and other places." From this period new tramways or railways were sanctioned in almost every session. The Acts by which the earlier railway companies were established followed very closely, in their general scope, the provisions which had been applied to canal companies. The promoters of the project were constituted a corporation, and were authorised to raise such money, either by shares or by borrowing, as they required for completing their undertaking; and they were empowered in their corporate capacity to take lands compulsorily, and to charge tolls at their discretion for the use of their railway, within the limits of certain prescribed rates, for various classes of goods. In the Act for the Liverpool and Manchester Railway, passed in the year 1825, and in other subsequent similar Acts, a further provision was introduced, that if the dividends should exceed 10 per cent an abatement should be made from the maximum tonnage rates of 5 per cent on the amount thereof for each 1 per cent, which the Company might divide over and above a dividend of 10 per cent on its capital. In their capacity as owners of a road, railway companies were not intended by Parliament to have any monopoly or preferential use of the means of communication on their lines of railway; on the contrary, provision was made, in all or most of the Acts of Incorporation, to enable all persons to use the road on payment of certain tolls to the company, under such regulations as the company might make to secure the proper and convenient use of the railway. But no sooner were railways worked on a large scale with locomotive power than it was found impracticable for the public in general to use the lines, either with carriages or locomotive engines; and the railway companies, in order to make their undertakings remunerative, were compelled, with the assistance of the persons who had been previously engaged in the carrying trade of the country, to embark in the business of common carriers on their lines of railway, and conduct the whole operations themselves.

In consequence of the increasing number of Railway Bills annually coming before Parliament, and the necessity for securing consistency in private bill legislation, the House of Commons, in 1837, appointed a select committee, to which were referred all petitions for private bills, and it was the duty of this committee to decide how far the standing orders had been complied with in each case.

In 1840, another Select Committee of the House of Commons, appointed to report on the railway system, came to the conclusion that the right secured to the public by the Railway Acts, of running their engines and carriages on the railways, was practically a dead letter. In consequence of their recommendation that the executive government should be entrusted with the duty of inspecting new lines of railway, and of exercising a general supervision over the manner in which the railway companies used their powers, an Act was passed by which it was provided that no new railway for the conveyance of goods or passengers should be opened without previous notice to the Board of Trade, and the Board were empowered to appoint officers to inspect all new railways. The Board was also empowered to require, under a penalty, that every railway company should deliver to them returns, in whatever form they might prescribe, of the traffic in passengers and goods, as well as of accidents attended with personal injury, and a table of tolls and rates from time to time levied on passengers and goods. All bye-laws already made by companies were to be certified to the Board, and no new ones were to be made without its sanction. The Board was also constituted the guardian of the public interests, being empowered at its discretion to certify to the law officers of the Crown any infraction of the law, and the law officers of the Crown were thereupon required to take the requisite legal proceedings. The power which had been conferred upon proprietors of land adjoining railways by their private Acts of Parliament, for making junctions, was placed under the control of the Board of Trade, with a discretion to regulate the manner in which it should be exercised.

In 1842, the returns of the accidents required to be made to the Board of Trade were extended to all cases, whether or not they were attended with personal injury; and in 1844 parliamentary trains were established by law, and the powers of the Board of Trade to compel railway companies to comply with the law were extended to all unauthorised proceedings on the part of the railway companies. In 1846 an Act was passed establishing a Board of Commissioners of Railways, to whom the powers possessed by the Board of Trade were transferred; but in 1851 the Board of Commissioners was abolished, and its powers and duties were re-transferred to the Board of Trade.

In 1857 a Select Committee on Accidents on Railways was appointed, who in their Report of the 25th June, 1858, classified the causes of accidents under the three following heads:—Inattention of Servants; Defective Material, either in the works or rolling stock; and Excessive Speed. Much stress was laid by the Committee on the necessity for punctuality in the departure and arrival of trains; they considered that it should be imperative on every railway company to establish a means of communication between guards and engine-drivers, and that a system of telegraphic communication on the lines should be enforced, in order that they might be worked on the block system; and they concluded by recommending that, with respect to signals, breaks, and other precautions, such details should be left to the management of the railway boards, but that the Boaro of Trade should be invested with further powers to enabd them the more effectually to control the working of railways with a view to diminishing the number of railway accidents.

Bills have at various times been introduced with the object of compelling railway companies to adopt some precise system of working, but they were not passed; and in 1866, in a bill of this nature, it was for the first time proposed to compel railway companies to adopt a means of communication between passengers and guards, and between guards and engine-drivers of all trains. This Bill, however, did not, at the time, become law, but was withdrawn.

In 1865 a Royal Commission was appointed to enquire generally into the subject of railways, and to report, amongst other matters, whether, with a due regard to the progressive extension of the railway system, it would be practicable, by means of any changes in the laws relating to railways, "more effectually to provide for securing the safe, expeditious, punctual, and cheap transit of passengers and merchandise upon the said railways."

Up to this date the legislation upon railways directed that no line should be opened until it had first been approved and passed by the Board of Trade Inspectors, but after it had been once opened for traffic the manner of working was left entirely in the hands of the railway company, power being, however, reserved to the Board of Trade to cause the railways, the engines, and the carriages to be inspected by their officers whenever they might think fit, and they might, when applied to, make regulations for the safe working of the traffic at the junction of the lines of two companies. The railway company, in undertaking the duty of carriers, became liable under the common law to compensate persons injured, and under Lord Campbell's Act to compensate the relatives of persons killed by the company's negligence or by that of their servants. Thus Parliament relied upon the principle of leaving the responsibility of the safe working of railways with the companies rather than upon giving the Board of Trade the power and duty of interfering in the details of management.

The Royal Commission of 1865, in their Report, expressed the opinion that the plan of relying for the safe working of railways upon the efficiency of the common law and of Lord Campbell's Act, had been more conducive to the protection of the public than if the Board of Trade had been empowered to interfere in the detailed arrangements for working the traffic. They recommended, however, that, on the one hand, railway companies should be absolutely responsible for all injuries arising in the conveyance of passengers, except those due to their own negligence; and that, on the other hand, the liability of the railway companies be limited within a maximum amount of compensation for each class of fares; but that any passenger should be entitled to require from the company any additional amount of insurance he might desire, on paying for it according to a fixed tariff. They also recommended that claims for compensation should not be admitted unless made within a certain period, and that the railway companies should have the right of medical examination of the claimant; and, further, that to the power already possessed by the Board of Trade of appointing officers to inspect railways and rolling stock, should be added a power for the inspecting officer to require the attendance of the officers and servants of the company as witnesses, and the production of books and documents bearing on enquiries directed by the Board of Trade; and that the reports of the inspecting officers on accidents should be made public.

In 1870 a Select Committee of the House of Commons was appointed to enquire into the law and the administration of the law of compensation for accidents as applied to railway companies, and also to inquire whether any, and what, precautions ought to be adopted by railway companies with a view to prevent accidents. On the second point the Committee pointed out that on those lines where the block system had been adopted it had materially conduced to the safety of the public, and they recommended the evidence collected by them on this subject, as well as that in favour of the principle of the interlocking of signals and points, and concerning continuous breaks, to the careful consideration of railway boards of directors.

Last year (1873) a Bill was introduced into Parliament for the "Regulation of Railways," with a view to the prevention of accidents. This Bill had for its object the enforcing upon all railway companies the obligation of securing an interval of space between trains following each other on the same line of rails, which is now generally effected by what is known as the block system, and it further proposed to enforce the interlocking system. A Select Committee was appointed by the House of Lords to consider this Bill, but whilst strongly recommending the adoption of both the block system and the interlocking system on all important lines of railway, yet, relying on the great exertions recently and very generally made by different railway companies to extend both systems, and other great improvements now in progress, the Committee recommended that the Bill should not then be proceeded with. They recommended, however, that the Board of Trade should call for such information as might enable the inspectors, in their annual reports, to state specially the progress made in their adoption on all passenger lines, after which, it was considered, Parliament would be in a condition to decide whether or not it would be right to require the further and more prompt extension of these systems on those lines where they might still be necessary.

Another Commission is at the present time occupied in considering how railway accidents may best be prevented, and what legislation, if any, is desirable on the subject in the interests of the public at large. It will be observed that, hitherto, the action of Parliament has been rather to recommend and advise than to pass coercive measures to compel railway companies to adopt improved means for the protection of their passengers. At the same time, additional powers have been vested in the Board of Trade from time to time for the more efficient inspection of lines open to the public, and there can be no doubt that the duties devolving upon that branch of the public service have hitherto been conducted satisfactorily in the general interests, but it is hardly to be supposed that its action should meet with universal approbation, or, indeed, that it should be always free from blame. It is very obvious that the officers of the Board of Trade are not in good odour with the present President of the Institution of Civil Engineers; and, as his observations may probably be taken to represent the feelings of railway officials generally towards them, we quote the following remarks made by him in his inaugural address on the 13th of January last:—

"There is also a 'popular delusion' which I think ought to be corrected. The public believe that the various recommendations made to the railway companies from time to time by the officers of the Board of Trade, such as the block system, interlocking of points, &c., are really inventions of those officers, whereas the fact is that not one of these systems or inventions, or any new idea in connection with the workings of railways, has ever really been suggested by them.

"The railway companies also are at a great disadvantage with the public in respect to the reports which are from time to time made by the Government inspecting officers—their dictum is never questioned by the public; and although railway officers of great experience constantly differ from those officials in the conclusions at which they arrive, the railway companies feel that any appeal against these reports is useless, and practically judgment is allowed to go by default.

"In making their reports, the officers of the Board of Trade are in the position of *ex post facto* judges, and I need hardly point out that there is a great difference, to use an expression of our late President, Mr. Hawksley, between looking into the events of the week that is past, and looking into the middle of next week; and should the country at any time become the purchasers of the railways, these officers will soon find the difference in their position when the responsibility of working the lines devolves upon them.

"Captain Tyler, in his valuable Report on Railway Accidents in 1872, says: 'Whatever be the amount of care taken, the item of human fallibility will still remain, and will always be the cause of a certain number of accidents.' And he states that in 180 cases of accidents out of 238, 'negligence, want of care, or mistakes of officers, were apparent.'

"This is a subject to which for years past I have devoted a great deal of attention and anxious thought, and I attach much more importance to the item of 'human fallibility' than Captain Tyler appears to do."

To these remarks Captain Tyler replied as follows, in a paper read by him before the Society of Arts in May last:—

"When Mr. Harrison attributes to the author that he does not sufficiently appreciate the element of human frailty as contributing to accidents on railways, and leaves it to be understood that improved arrangements will not materially lessen the number of accidents and their serious results, the author would venture to reply that he estimates that cause of accident at no more and no less than has actually been found by experience of many years to attach to it."

This subject also was referred to by the Select Committee of the House of Lords, who, in their report of last year, remarked:—

"It may be confidently stated that the general safety of railway travelling would be increased by the more extensive employment of the block and of the interlocking systems. Some witnesses stated that these precautionary arrangements and mechanical appliances tend to lessen the sense of responsibility in the engine drivers. Such an effect may have been produced, but, nevertheless, the advantages resulting from the introduction of these systems are practically admitted by all the witnesses, and, in the judgment of the Committee, decidedly preponderate."

We do not propose to follow up this subject further at present, beyond remarking that, whilst fully admitting the element of human frailty, which must exist wherever the hand of man is engaged, we entirely concur in the conclusion arrived at by the Select Committee of the House of Lords, that the introduction of improved mechanical contrivances for the more efficient and safe working of railways is likely to overbalance in its advantages the evils likely to arise from the element of "human frailty," which must be, at all times, inseparable from their introduction.

The next subjects for consideration are the extent to which railway passengers are liable to accidents, and how far former risks are increased or diminished in proportion to the number of travellers, and to the adoption of means with a view to their prevention. A general review of the number of fatal accidents to passengers from all causes beyond their own control, between the years 1847 and 1873 inclusive, is contained in Captain Tyler's General Report to the Board of Trade on the accidents which have occurred on the railways of the United Kingdom during the year 1873, from which the following extract is taken:—

"The total number of persons recorded at the Board of Trade as having been killed on railways during the year was 1372, and the number of injured was 3110. Of these, 160 persons killed, and 1750 persons injured, were passengers; and the remainder, 1212 killed and 1360 injured, were officials or servants of the railway companies, or trespassers, or others who met with accidents at level crossings, or from miscellaneous causes. Of the passengers, 40 were killed, and 1522 were injured, from causes beyond their own control. The total number of passenger-journeys having been 455,272,000, it follows that the proportion of passengers killed was, in round numbers, 1 to 2,845,450, and of passengers injured 1 to 260,155; and that the proportions of passengers killed and injured from causes beyond their own control were respectively, 1 in 11,381,800, and 1 in 299,127. This was a decrease on the average of the number killed, and an increase of the number injured, from causes beyond their own control, in the previous three years, in which the proportions were 1 to 11,123,931 killed, and 1 to 357,000 injured. Of the officers and servants of railway companies there have, during the past year, in proportion to the total number employed, as nearly as they can be estimated (say 250,000), been killed from all causes 1 out of 323, and injured 1 out of 213; but accidents to servants do not appear, in many cases, even now to have been reported by certain of the railway companies, and their numbers would, if the whole truth could be ascertained, be considerably increased.

"The following statement shows the proportion of passengers killed to passenger-journeys for the three years ending 1849, the four years ending 1859, the four years ending 1869, and the four years 1870, 1871, 1872, and 1873, respectively :—

Year.	Number of passengers killed from all causes beyond their own control.	Number of passenger-journeys exclusive of journeys by season-ticket holders.	Proportion killed to number carried.	
1847 1848 1849	36	173,158,772	1 in 4,782,188	
1856 1867 1858 1859	64	557,338,326	1 in 8,708,411	
1866 1867 1868 1869	91	1,177,646,573	1 in 12,941,170	
1870	66	336,545,399	1 in 5,099,172	Average of these 3 years, 1 in 11,123,931
1871	12	375,220,754	1 in 31,268,396	
1872	24	422,874,822	1 in 17,619,784	
1873	40*	455,272,000	1 in 11,381,800	

From these figures it appears that the average of fatal accidents for the last four years was higher than in the similar cycle immediately preceding; and the conclusion that would naturally be formed at first thought is, that a maximum of safety in railway travelling has been arrived at. On a closer examination, however, it does not in any way seem that this is the case. No doubt traffic has increased on many lines in a more rapid ratio than the development of increased accommodation for such traffic. But the accidents in 1870 were considerably in excess of the proportion given in the above table since 1856; but if we omit that bad year, and take only the average of the last three years, it will be seen that the number of passengers killed from all causes beyond their own control was only 1 in 20,089,993, which shows a considerable improvement upon any of the earlier periods referred to. The year 1871 was, it appears, exceptionally free from fatal accidents; but Captain Tyler shows that it is not desirable to lay too much stress on the results of working in the case of any particular year, either as to the number of sufferers or as to the number of accidents. More returns of accidents than formerly have been rendered by the companies within the last two years. Inquiries have also been instituted during those two years into a greater proportion of cases, and there is, humanly speaking, much of chance in both. A dangerous or defective mode of working is frequently carried on for a great length of time without bad results, while there are accidents and loss of life where greater precautions have been adopted, or less risk is apparently incurred. A comparatively trifling defect may in one case lead to much loss of life, whilst important defects may, in another case, be unattended with accident.

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* The deaths of two of this number were not the results of train accidents

Setting aside considerations of humanity, the railway companies have a positive and direct pecuniary interest in the avoidance of accidents, and capital laid out with that object in view is not likely to be wholly unproductive. Under Lord Campbell's Act the railway companies are pecuniarily liable to those to whom any injury is caused by accidents, &c., on their lines, and, during the ten years from 1848 to 1857 inclusive, there was paid as compensation on account of passengers and goods injured on fourteen lines of railway, no less a sum than £414,440, or at the rate of over £40,000 a year. For the five years ending with the year 1871, there was similarly paid £2,348,568, of which £1,622,370 was as compensation for personal injury, and £726,198 as compensation for damage to goods. These sums do not, however, include anything on account of injury to the servants of the railway companies, to whom the latter are not liable by law in the same way that they are towards their passengers or goods traffic.

The following table shows the number of train accidents that have formed the subject of inquiry, and have been reported on, by officers of the Board of Trade, during the past four years. The number of cases inquired into during the preceding five years averaged 83 per annum, upon which those for the year 1870 show an increase of 57 per cent:—

1870.	1871.	1872.	1873.	Cause of Accident.
9	19	21	24	From engines or vehicles meeting with, or leaving the rails in consequence of obstructions, or from defects in connection with the permanent way or works.
10	22	17	23	From boiler explosions, failures of axles, wheels, tyres, or from other defects in the rolling stock.
61	9	22	18	From collisions between engines and trains following one another on the same line of rails, excepting at junctions, stations, or sidings.
	63	91	98	From collisions within fixed signals at stations or sidings, &c.
18	19	32	20	From collisions at junctions.
3	2	5	3	From collisions between trains, &c., meeting in opposite directions.
1	—	—	3	From collisions at level crossings of two railways.
14	12	34	36	From passenger-trains being wrongly turned or run into sidings, or otherwise through facing points.
—	2	7	5	From trains entering stations at too great speed.
6	11	9	11	On inclines.
9	12	8	6	Miscellaneous.
131	171	246	247	

An examination of this table will show that the more serious classes of accidents are evidently upon the increase, more particularly from collisions within fixed signals at stations or sidings, and from passenger trains being wrongly turned, or run into sidings, or otherwise through facing points. But it must be observed that the accidents are in no respect proportionate to either the length of, or the amount of traffic on, any particular line of railway, some lines being particularly unfortunate in this respect, while others enjoy comparative immunity from accidents. Increase of traffic, high speed, and variations of speed, tend materially to increased risk, to greater numbers of accidents, and to more severe accidents when there is insufficient accommodation in lines and sidings, when signal and point arrangements are defective, when the means of securing intervals between the trains are defective, without sufficient break-power, without good construction and high maintenance, and when the appliances and apparatus are not adapted to the exigencies of the traffic. But when, on the other hand, the accommodation is sufficient to enable the traffic to be worked under safe conditions, when high speed is employed only over a good permanent way in suitable portions of railway, and under proper circumstances, and when good arrangements are made to preserve intervals between the trains, of whatever class, then such extra risk may be in a great measure obviated. Some of the great railway companies have made, and others are making, great progress in providing the necessary remedies. It was stated by Mr. T. B. Farrer, in his evidence before the Select Committee of the House of Lords last year, that the railway companies had then already spent upon the introduction of the block system and the system of interlocking signals, between £700,000 and £800,000, and that they were proposing to spend a great deal more; on a previous occasion, however, it had been stated before the same Committee, by Mr. J. S. Farmer, that, in his opinion, a great deal of expense had been thrown away in tinkering at the signals, in trying to do as little as possible, instead of grasping the thing comprehensively in the first place.

However much has already been accomplished, a good deal yet remains to be done, especially on certain railway systems; and Captain Tyler expresses it as his opinion that it is partly on account of sufficient attention not having been paid in previous years to the various means of safety that some of the great railway companies now appear so unfavourably at the head of the accident list, and partly also because they have found it difficult, with constantly increasing traffic, simultaneously to make up for past omissions and to keep up with present requirements.

In a circular letter addressed by the President of the Board of Trade to the several railway companies in November, 1873, on the subject of the great increase in the number of railway accidents during 1872, Mr. Chichester Fortescue remarked that a large proportion of these casualties appeared to have been due to causes within the control of the railway companies. "If it may be contended," the circular goes on to state, "that the traffic on many lines has very greatly increased, and with it the risks of railway travelling, it is no less true that it is within the power of the companies to take care that the permanent way, the rolling stock, and the station and siding accommodation, are kept up to the requirements of the traffic; that the officers and servants are sufficient in number and quality for the work to be done, and that proper regulations for their guidance are not only made, but enforced; that pains are taken to test every reasonable invention and expedient devised for the purpose of preventing danger; and that such of those expedients as experience proves to be effective are adopted without undue delay.

"In the face of the facts collected and analysed by Captain Tyler, and of the numerous accidents of the present year (many of them the subject of Board of Trade enquiries) it is difficult to suppose that such is the case.

"There can indeed be no doubt that methods of working and mechanical contrivances, the value of which has been thoroughly ascertained, have been too slowly introduced, and that there is great reason to believe that sufficient provision has not been made for the safe working of the increased traffic by the enlargement or re-arrangement of stations and sidings, and the laying down of additional lines of rail.

"But whatever may be thought of these and othes causes as contributing to the result, the present insecurity of railway travelling imposes upon the railway companies the grave responsibility of finding appropriate remedies for so great an evil."

On the subject of the frequent unpunctuality of trains it was remarked, "The inconvenience, vexation, and loss caused to passengers by this breach of the conditions upon which the companies profess to carry them, constitute in themselves a serious subject of complaint. But the evil arising from unpunctuality does not end here. The service of the line is disarranged; the chances of accident are multiplied; the trains are forced, in order to make up for lost time, to travel at excessive speed through complicated stations, or under other circumstances where such travelling may be equally dangerous."

It is further remarked that the returns of accidents to railway servants show a lamentable number of casualties, often fatal, in proportion to the numbers employed; and, finally, a hope is expressed that the railway companies themselves "will make every effort to meet the reasonable demands of the public and of Parliament."

The Board of Trade, as the branch of the Government which has to look after the interest of the public in respect to railway travelling, for which purpose it has been invested with special powers, could not with any degree of propriety have passed over, without some special notice, the alarming increase in the number of railway accidents recorded in 1872, which had increased nearly 44 per cent over 1871, 88 per cent over 1870, and 196 per cent over 1869. It is not proposed to consider, separately, the replies to this circular which were sent to the Board of Trade, as the remarks which they contained with reference to the principal causes of accident prevailing on railways, will be noticed further on under the different headings to which they respectively belong.

The means of safety which the accidents occurring last year show to be required, are thus given in the last General Report to the Board of Trade :—

1. The judicious selection, training, and supervision of officers and servants, and the preservation of good discipline.
2. Maintenance in high condition of the permanent way.
3. Good design, construction, and material of axles.
4. The application of tyre fastenings which will prevent the tyres from flying off the wheels in the event of fracture.
5. Improved coupling of vehicles in trains.
6. Signal and point arrangements with modern improvements, including concentration and interlocking of the signal and point levers, and locking-bolts and locking-bars for facing points.
7. Safety points to goods or siding connections with passenger lines.
8. Increased use of the telegraph, with block-telegraph systems for securing intervals of space instead of illusory intervals of time only between trains.
9. Sufficient siding accommodation for the collection, distribution, and working of goods traffic, so that goods trains may be shunted and marshalled independently, and kept out of the way of passenger trains, and may not encumber and endanger the traffic on the main lines.
10. Continuous breaks, to be worked by the engine-drivers as well as the guards, as occasion may require.

We propose to consider these several means for providing increased security to railway traffic under the following headings, viz.—1. Efficiency of Staff. 2. Maintenance of Permanent Way. 3. Maintenance of Rolling Stock. 4. Signals and Points. 5. Telegraph, and the Block System. 6. Siding Accommodation. 7. Break Power.

1. *Efficiency of Staff.*—It will be readily understood that, all mechanical appliances for ensuring safety being perfect, the efficiency, both as regards strength of establishment and individual intelligence, on the part of the railway staff is yet necessary in order to secure freedom from accident and danger. Even under the most perfect organisation, however, the fallibility of human nature must ever be a bar to the attainment of absolute security, but the risk may be lessened to the last practical limit by the maintenance of a fully efficient staff, and the strict enforcement of all regulations laid down for their guidance. In a paper on "Railway Accidents" read before the Institution of Civil Engineers as far back as April, 1862, Mr. James Brunlees, the author,

observed that the negligence of servants, their payment, and their hours of working, were matters of the greatest importance, and he remarked that most of the accidents caused by negligence might be traced to ignorance or to inefficiency. The wages usually given by railway companies were too low to command the services of men of intelligence, steadiness, and self-reliance, and, in consequence, inferior men were employed, who were incapable of appreciating the importance and necessity of executing their duties with promptness and exactitude. In the official report to the Board of Trade on railway accidents for the year 1870, Captain Tyler remarked, after enumerating the accidents of the year under their respective headings: "Accidents from all the above causes are more or less preventible, except in so far as it will never be possible, under the best arrangements, altogether to avoid accidents from negligence or mistakes on the part of employés, although it is practicable, under good arrangements and systems, and with good discipline, very much to reduce their number."

In the year 1871, out of 171 investigated accidents, there had been in 121 cases of negligence, want of care, or neglect of servants; in 1872, out of 238 cases, 180 were due to negligence or mistakes of officers or servants, and in 1873, out of 241 accidents, a similar negligence was apparent in 182 cases.

Whatever be the means and appliances provided, or the amount of care taken, the item of human fallibility will always be the cause of a certain number of accidents. But the number of accidents from this cause, as was remarked by Captain Tyler in his report for 1873, may be very much reduced by "improvements in regulations and discipline, by greater care in the selection, training, payment, and employment of competent men in sufficient numbers and for reasonable hours, and by providing them with the requisite siding and other accommodation, with proper signal and point apparatus, with the best means of securing intervals between trains, with sufficient break-power, and with other necessary appliances." It has been argued that railway servants are apt to become more careless in the use of these improvements, in consequence of the extra security which they are believed to afford; but, whilst Captain Tyler remarks that by the results of more extended experience this argument has received further confutation, Mr. Harrison, the President of the Institution of Civil Engineers, and no mean authority on railway matters, stated, in his inaugural address, that there was an undoubted tendency on the part of engine-men and other railway servants to believe that all these arrangements of the block system and additional signals do, in fact, provide for their safety, and that consequently they do not keep the same look out, or use the same care that they would do on a line apparently less protected, "and that this is the case," he remarked, "observation and inquiry have clearly demonstrated."

Here, then, we find two leading authorities at issue in regard to a statement of fact, and it is, of course, very difficult to draw a fair conclusion between the two. The result of Mr. Harrison's experience seems to prove that, at present, railway servants have not become sufficiently experienced in respect to the true value of signals, and other means of safety on railways, but there is surely reason to hope that, as a body, they possess sufficient intelligence to enable them in time to appreciate more fully the extent to which these safeguards are valuable, and how much also depends upon their individual discretion.

In respect to enforcing discipline, Mr. Harrison observes that the difficulty is becoming constantly greater, as dismissal is no longer a punishment, when employment can at once be had elsewhere; and a reprimand is constantly met with the reply, "Oh! very well, I'll go." This gentleman has found that nothing attaches men more to the service of a railway company than giving them comfortable cottages, with gardens to cultivate.

The efficiency of the staff on a railway depends mainly upon three circumstances: First, the selection of none but respectable and tolerably educated men; secondly, the establishment of a fixed code of rules for their guidance, and seeing that those rules are strictly enforced; and, thirdly, the maintenance of an efficient number of men to do the required work; the payment of liberal wages, so as to keep them in the service; the holding out of prospects of promotion to the most efficient; and the proper treatment of them whilst in the service.

No doubt all modern improvements on railway working tend to increase the expense to the railway companies, but this is a matter for which there is apparently no remedy. "The question of the effect of the labour market on railways, both in their construction and working," says Mr. Harrison, "has come forcibly home to every one connected with them. It is not too much to say that all new works are now costing from 30 to 40 per cent more than they did a few years ago, and nearly double the time is required to complete them."

As will be shown further on, the adoption of the block system on all lines will necessitate a considerable increase of staff for working it, and with these additional elements of "human frailty" there will evidently exist an increase in the numbers of those to whom the safety of the travelling public will be entrusted, and increased safety can therefore only be expected to result if the rules laid down for the guidance of the companies' servants are, in the first instance, judiciously framed, and afterwards rigidly enforced.

2. *Maintenance of Permanent Way.*—The accidents caused by defects in permanent way are, happily, not nearly so numerous as they were in former years. The art of constructing railways, in the first instance, and of properly maintaining them afterwards, is so much better understood now than formerly, that accidents arising from defects in its observance would be a great slur upon the professional officers of any company. In the year 1854, thirteen accidents occurred from the defective condition or neglect of the permanent way. In the following year thirty-one cases arose from the same causes, but in the year 1856 there were fewer accidents of this description, which fact may be attributed to the greater attention given by engineers to the permanent way, and to the introduction of the fished joint, and of other improved methods of connecting rails. In the year 1857 twenty accidents were caused by the neglect, or imperfect condition, of the permanent way; in four of these the permanent way had been neglected, and in five it had been constructed in a defective manner. In 1858, twenty-nine accidents, and in 1859 fourteen accidents, were due to the state of the permanent way.

In commenting on this class of railway accidents, due to permanent way defects, which occurred during 1870, Captain Tyler stated that only nine were attributable to the conditions of the way and works, or to obstructions on the permanent way, &c. "This," he observed, "is a great improvement upon former years, when, say ten years ago, 16 per cent of railway accidents were caused principally by defects of permanent way; and the improvement is due, partly to the increased strength in some cases of rails and chairs, partly to placing the sleepers in some cases nearer together, and especially to the disuse of wooden trenails for attaching the chairs to the sleepers, and to the now almost universal employment of fish-joints for fastening the ends of the rails together." As to the remedy suggested for this class of accidents, it is remarked that next in importance to proper maintenance, and even as part of it, is the question of discipline amongst those employed in repairs, with a view to ensure, as far as possible, that due warning shall be given to the engine-drivers when a rail has to be taken out, while the road is being lifted, or whenever the line is not in a fit condition to be run over at speed.

Twenty-six accidents occurred in 1871 owing to defects of construction. These defects, it was then pointed out, were not as promptly corrected as they ought to have been, as new materials were supplied, on many lines of railway; each company, or each individual officer, waiting too often to buy his own experience, and profiting too little by the experience of other companies. Defects of maintenance, which appeared in nineteen cases, occurred partly from the over-work of materials, and partly from the want of more careful supervision, and of more careful record and comparison, from which much valuable information might be obtained. The number of accidents due to defective construction of road or works was four in 1872, and six in 1873, and to defective maintenance of the same, sixteen in 1872, and twenty-four in 1873.

It may perhaps be considered that forty accidents in one year, upon all the railways in the United Kingdom, due to defective construction or maintenance, is hardly above the number that might be expected to occur from such causes, considering the vast amount of traffic which now takes place in the neighbourhood, more particularly, of large towns and cities, but it must be remembered that these constitute a class of accident which is preventible by the exercise of due care on the part of the permanent way staff, and proper supervision during construction. It is, therefore, one which should not be seen in the official returns, unless accompanied by some such causes as exceptional floods, or other reasons to show that they were not occasioned by any laxity of duty or neglect of ordinary precautions on the part of the railway company or their officials.

3. *Maintenance of Rolling Stock.*—With regard to locomotives, instances do rarely occur—and they were more common in former than in recent years—of boiler explosions, due in some instances to want of proper care in the selection of water for their use, and in others, to a faulty mode of staying the boiler. These causes of accident are to be avoided by frequent inspection, by which the earliest intimation of any deterioration may be obtained, and the employment of weakened or worn-out boilers be discontinued. During the seven years from 1854 to 1860 twenty-one locomotives exploded, but in the annual returns

to the Board of Trade only two accidents from this cause are stated to have taken place in 1870, and two in 1873; no record of a similar accident appearing in the two intervening years.

The most common accidents to rolling stock are the breaking of the axles and wheel tyres. These cases may be traced generally to one or other of the following causes: sometimes they occur in the winter months, owing possibly, in some degree, to the rigid state of the permanent way in frosty weather; some are due to the use of bad iron or steel, and others to defects either in the welding of, or in the mode of attaching, the tyres of wheels. The existence of flaws in either axles or tyres may completely escape detection until they are discovered upon the occurrence of an accident, and such cases must be included amongst the risks which cannot be foreseen or avoided. The high speed at which trains travel as a general rule must subject both tyres and axles to very severe blows and jerks, especially when passing over points, or portions of line that are out of repair, and uneven, and it is in such cases that flaws or cracks are most likely to result in a complete fracture. "There is no satisfactory test," said Captain Tyler, in his report for 1870, "to which axles can be subjected from time to time in the course of running, as far as is known, by which flaws can be detected." With regard to fracture of tyres, it was stated in the same report that in two cases the tyre was attached to the wheel by means of rivets through holes bored in the tyre, and it was remarked that the "old system of boring holes through the tyres is essentially a vicious one, and is particularly undesirable in the case of steel tyres. It affords no security in the event of fracture, and even leads to increased risk of fracture, in consequence of the weakening of the tyre at the sides of the rivet holes."

In 1871 there were twenty-two accidents of this class, in which three persons were killed and thirty-four were injured; in 1872 there were seventeen accidents, occasioning the death of two passengers and five servants of companies, and injury to forty passengers and eight servants of companies, whilst in 1873 there were twenty-three accidents owing to the same causes, killing ten passengers and two servants of companies, and injuring fifty-four passengers and seventeen servants of companies. The chief methods recommended for adoption with a view to avoiding accidents from the breaking of tyres, consist in the use of improved modes of fastening them to the rims, so as to prevent them from flying off the wheel. They may fail from the brittle nature of the material, or from defects of manufacture, or from being too tightly shrunk on the wheel, and they have frequently failed from one of these causes, or from a combination of them. The danger consists, not in the fracture, or in the tyre becoming divided, whilst running, into two or more parts, but in the probability of the tyre, which is, or ought to be, in a state of tension on the wheel, flying suddenly and violently from it when fracture occurs, and this danger is greater with steel than with iron tyres.

3. *Signals and Points.*—During the seven years from 1854 to 1860 inclusive, as many as eighty-eight accidents happened from the use of improper or inefficient signals. Accidents have been caused by the total want of signals, especially at sidings, others have arisen from their defective form, or from their bad position. Many accidents have occurred in connection with distance signals; in some cases they have been placed so near to the station that the engine-driver has been unable to stop within the space allowed. It was observed by Captain Tyler in 1870, that out of sixty-one collisions, independent of the collisions at junctions or level crossings, thirty-one, or more than half of them, were due to defective arrangements with regard to signals or points, but that in twenty-eight cases out of these negligence was combined with the defects, and that the latter contributed more or less to the negligence; and out of eighteen collisions at junctions there were ten cases in which defective signal and point arrangements were the cause. In 1871 there were fifty-three accidents caused by defective signal and point arrangements, or want of locking apparatus; in 1872 the number of accidents due to similar causes was seventy-one, and last year it was seventy-eight, so that this cause of accident would appear to be growing rapidly in importance.

When trains were few, and the speed at which they travelled was moderate, a comparatively crude method of signalling sufficiently answered every purpose; with the increase of trains, the complications of junctions, and the greater difficulty that consequently existed in controlling a number of signals at any one point, it became necessary to place all the signal and point levers in or around the signal cabins; and, in order to afford a better view to the signalman, the cabins were raised to a greater or less height above the ground, and placed in convenient situations, according to local circumstances. But even then, when the control was more conveniently placed in the hands of one man, there was still, as the levers in or near a cabin became more numerous, a liability to mistake, from the signalman pulling over a wrong lever; or the levers were fastened over by blocks of wood, which the signalman forgot to remove; and to prevent such mistakes, and serious accidents resulting from them, it became further necessary to interlock the levers with one another. By 1860 many improvements had been introduced upon the interlocking system, and the inspecting officers of the Board of Trade began to insist on the use of locking apparatus at the junctions of new branches with existing lines.

By the application of locking and other apparatus it is possible to prevent nearly all accidents from collision occurring, in the ordinary way of working, in consequence of any mistake of the signalman. Conflicts between signals, and conflicts between points and signals, may alike be avoided; and a good combination of locking-bar and bolt may be made to insure that the facing points are completely over before the proper signal is lowered, and may also prevent them from being moved during the passage of a train. It is, of course, impossible to provide against all the contingencies which may arise—such as, in certain cases, against the absolute neglect of drivers to pay attention to the signals made to them; or such as a signalman, when two trains are running towards a junction at one time, setting his points and lowering his signals first for one of them, and then altering them and preparing for the second train, without allowing time for the first train to stop short of the junction. But provision may be made, and is made to some extent, even for the contingency of an engine-driver neglecting to obey signals.

In a paper recently read before the Institution of Civil Engineers, by Mr. R. C. Rapier, a detailed description of signals and points was given, besides an account of different methods of interlocking the two, so as to avoid accidents which might occur in the event of wrong signalling. It would be impossible to follow out that paper in detail here, but we may briefly state that it was there shown that the mere connection of switches and signals was not sufficient, but that effective interlocking required the movement of the switches to be completed before the alteration of the signals could be made, and *vice versa;* whilst, as regards facing-points, it was stated that, although it was desirable to avoid them as much as possible on a line of light traffic, the use of facing-points, properly controlled, might be made one of the greatest safeguards where trains were frequent, and travelled at different rates of speed.

5. *Telegraph and the Block System.*—In two papers on "Railway Accidents," by Mr. Brunlees and by Captain Galton, read at the Institution of Civil Engineers in 1862, it was deduced from statistical tables that the great majority of accidents were attributable to preventible causes, and that, of these, 27 per cent were due to the absence of the electric telegraph. The advantages of the telegraph in connection with the working of railways were dealt with in an able paper by Mr. W. H. Preece, which was read at the Institution of Civil Engineers so far back as January, 1863, and although all the views expressed by him on the subject at that time have not met everywhere with approval or adoption, the system generally has come to be recognised as absolutely necessary for the safe working of any line of railway, and it forms a most important element in the now universally adopted block system.

The first attempt of a block system introduced on railways was by maintaining a presumed time interval between trains; this plan, however, failed, because those intervals could not in practice be observed; and the permissive system for reducing the time intervals by the aid of the telegraph, and sending trains timed to travel, and capable of travelling, at various speeds, one after another, into the sections, with a caution to each, may also be considered to have failed, because it does not afford sufficient protection to the traffic. Under these time systems collisions have occurred from engine-drivers slackening their speed to avoid collision with trains in front of them, and being run into by trains behind them. The greater the variety of speed between the trains, the more does the weakness of such systems become apparent.

The proposal to divide the line of railway into telegraphic sections, and thus to preserve space intervals between trains, was made by Mr. (now Sir William) Cooke, as far back as 1842, and was first practised, it is believed, on a portion of what is now the Great Eastern Railway, in 1844; and, subsequently, a train telegraph system was established on portions of the London and North Western Railway. This latter, however, was not a block system, or a space system, but a time system worked with the aid of telegraph instruments, and it is now known as the permissive system. As regards the block system, there are many descriptions of instruments for working it, and various rules and regulations applicable to it on different lines of railway. The main principle involved is simply by the division of a line into block sections, and allowing no engine or train to enter a block section until the previous engine has quitted it, to preserve an absolute interval of space between engines and trains. This may be done mechanically or electrically. Any means of communication with which the signalmen may be provided will enable them to inform one another of the approach of a train, of its entrance into a block section at one end, and of its exit from that block section at the other end.

Mr. Harrison, the President of the Institution of Civil Engineers, has stated that the block system will, as soon as it is possible to complete the necessary works, be introduced throughout the whole of the railways in England. It was stated by Mr. Farrar, before the Select Committee of the House of Lords last year, that the railway companies had already spent upon introducing the block system, and the system of interlocking signals, between £700,000 and £800,000, and they were proposing to spend a great deal more. Besides this expense there is a considerable annual cost to be incurred in working those systems; the increased cost of the staff alone is estimated for the Great Eastern Railway at £13,860, and on the Midland at £130,000 per annum. In the case of the North Eastern Railway it is calculated that on the completion of the block system, the number of signalmen will be increased from 500 to 2000. Mr. Rapier, in his paper to which we have already referred, shows that the probable cost of the interlocking and block system on fourteen of the principal railways would be about ½ per cent on the whole cost of the lines, and that then their carrying power might be so increased that three times as many trains could be run on the block system as without it, and with greater safety. The probable cost of maintaining the block system was stated to be about 2½ per cent on the traffic receipts, and this comparative percentage was less on the lines which had a great number of points to protect than on some of the light traffic railways.

6. *Siding Accommodation.*—It was pointed out in the Report to the Board of Trade on Accidents that occurred during 1871, that collisions at stations often occurred from the want of accommodation at the stations or sidings, passenger lines being unduly obstructed from the want of sidings in which to place slow or stopping trains, or in which shunting may be performed. The same deficiency of accommodation may also be the indirect cause of collisions on the line between stations, when, for instance, from the want of siding accommodation, a slower train is despatched in advance of a faster one, without a sufficient

interval between them to allow of its proceeding forward to the next place of refuge before it is overtaken, and it is stated that the want of improvement in, and addition to, the siding accommodation, combined with the want of modern appliances for working the points and signals from suitable cabins, and interlocking the levers with one another, and of telegraph-working for assisting in protecting an obstructed station, have principally to answer not only for the accidents themselves, but also for the negligence of the servants by which those accidents were more or less directly occasioned.

7. *Break Power.*—The subject of break power is one of especial importance, many lives and much property being hourly dependent, in a greater or less degree, on the power and efficient state of the breaks. It has been found that most of the collisions which have occurred might have been prevented had those in charge of the trains possessed the power of stopping within a few hundred yards. This is more particularly necessary on account of the high speeds and heavy trains now adopted on all lines. It is therefore essential that there should be ample break power to each train, and, whatever system may be adopted, it should be powerful, simple, and capable of being applied in the shortest possible time. On certain railways, where the necessities or convenience of the companies have been the means of inducing more rapid improvements in this respect, systems of continuous breaks have for many years been in successful operation; and the experience of these lines has left no doubt of the value of such systems of breaks. Amongst the simpler means of providing extra break power are—increasing the numbers of guards and of break-vehicles; enabling a guard or breaksman to apply the breaks of two adjacent vehicles; allowing the guards and breaksmen to walk through the trains, and to apply the breaks of the various vehicles provided with them; or by such a system as may enable a guard from his own van to apply the breaks of several vehicles, in which may be combined an economy in guards with efficiency in break power. In the use of any good system of this description, it becomes unnecessary to skid the wheels of break-vehicles, and flat places in the wheel tyres are thus avoided. Perhaps the most perfect system of continuous breaks yet introduced is that which enables the engine-driver to control the train, and by means of compressed air to apply all the breaks at once without the development of any manual exertion.

The limit of space to which we are necessarily confined for a single article has prevented any detailed account of the various methods of intercommunication in trains, which, by the Regulation of Railways Act of 1868, is directed to be provided in every train carrying passengers and travelling more than twenty miles without stopping, or of the several other minor arrangements suggested, or introduced, with the view of more effectually securing the safety of passengers.

With the adoption of the improved methods of interlocking signals and points, and of the block system, no doubt very considerable addition is made to the safety of travellers, but the companies are thereby put to great additional expense, both in first cost and for subsequent maintenance, for which the only return they can look to is an increased immunity from accidents. To ensure absolute security is not, however, possible, by the adoption of any means hitherto suggested. The introduction of the block system necessitates the maintenance of a considerably increased staff of signallers, and at the same time it introduces so many additional elements of human fallibility, whose liability to err can only to a limited extent be guarded against by the employment only of competent men, and the strict enforcement of such rules and regulations as it may, in each case, be considered advisable to frame for their guidance.

III. HUMAN LEVITATION;

ILLUSTRATING CERTAIN HISTORICAL MIRACLES.

ACCORDING to Archbishop Trench, a physical definition of man might be given as "the animal that weighs less when alive and awake than dead or asleep" ("Notes on the Miracles," ed. vii., p. 289). This he calls "a fact which every nurse who has carried a child would be able to attest;" and refers to Pliny ("Natural History," vii., 18). He concludes, "that the human consciousness, as an inner centre, works as an opposing force to the attraction of the earth, and the centripetal force of gravity, however unable now [*i.e.*, since Adam's fall] to overbear it." Unluckily, Pliny's words do not make this form of psychic force a human prerogative. They are, "Mares præstare pondere; et defuncta viventibus corpora *omnium animantium*, et dormientia vigilantibus." Perhaps, even in the absence of any accurate experiments, we might pretty safely say this very broad statement is unproved—that some animals might be found in whose weight, awake and asleep, or alive and dead, our most delicate balances would not detect a difference. It is said to have been so with the fish, alive and dead, about which our "merry monarch" suggested to the founders of the Royal Society one of their first subjects of inquiry. But it was not pretended to be settled without experiment; nor does it now appear how the Archbishop and his authorities, the nurses, could be contradicted as yet by anything short of direct and special experiments, and those not very easy, nor likely to be made with much accuracy to-day or even to-morrow. The monarch's joke (if such it were) was said to impress a lesson on the scientific men; and it really seems as if the archbishop's bit of traditional physics might unwittingly teach one greatly needed by those of the present day, who repeat, *ad nauseam*, that in their studies experiment has superseded dogma, whatever may be the case in other subjects. Le Play names the following authors as pledged to this position, "Les sciences physiques, disent les nouveaux docteurs, n'assignent à l'homme aucune place exceptionelle dans la nature; car il se confond par des transitions insensibles avec les autres animaux.* MM. Baumgartner, Büchner, Burmeister, Cotta, Czolbe, Feuerbach, Giebel, Huschke, Löwenthal, Lotze, Moleschott, Muller, Orges, Rossmässler, Strauss, C. Vogt, R. Wagner, Zimmermann." He invites any of them to correct him if they are misrepresented by this sentence from Büchner's "Force et Matière," 1865, p. 234. "The best authorities in physiology are now sufficiently agreed that the soul of animals differs not from the human soul in quality, but only in quantity." Now, without implying that Trench's dictum above is anywise better founded, or that a physical difference between human and brute soul can or ever will be detected, we would humbly ask, supposing two physical propositions like the following were made—which are not so absurd as plenty that have had to be met, and very laboriously demolished—could any or all of those eighteen physicists, or all European science, lay hands to-morrow on disproof thereof? Supposed proposition:—"(1). That between the weight of every adult man (or, say, male white), with and without his soul, *i.e*, alive and dead, there was a difference of a drachm and a quarter; but (2) that in the case of no brute animal (or, say, no woman or no negro) was there a thousandth of this difference; or, if you please, always a difference in the contrary direction," so that the human and brute soul (or the male and female human, or the European and the negro) should be so widely different physically as for the one to possess gravity and the other levity: would there, in any of these cases, be any record of experiment to this hour that could negative the statement? If not, then who, the theologian or the scientists, are the rasher dogmatists, or the more unphilosophical?

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* L'Organisation du Travail, pp. 231-2.

Surely Faraday had done all his teaching before that wonderfully unlucky dictum, that investigators ought to approach an inquiry with "preliminary notions of the naturally possible and impossible." It amounts to this, that before investigating whether nature contains *x*, you ought to know what nature does and does not contain. A tolerable attainment truly. The only man we have known, and perhaps the first, to claim this sublimity of knowledge, was Daubeny, who, in the stir raised by Colenso's denial of Noah's story, or, rather, the saying of Christ about "the day that Noë entered the ark, and the flood came and took them all away," deigned to assure the clergy (in their paper "The Guardian"), and, apparently, to their satisfaction, that "nature evidently" [to botanical professors] "contains no forces competent to produce" the described catastrophe. Faraday's requirement then is even exceeded; here is knowledge not only of what the universe contains, and does not contain, but of what it did or did not many centuries ago! But we are wrong in calling his knowledge unparalleled. Here is a perfect parallel elicited by the very same subject, "The Noaic Deluge," by the Rev. S. Lucas, F.G.S., a writer just as certain (from Geology) that such deluge happened, as Colenso and Daubeny that it did not. At page 2 of this little book, Mr. Lucas says, "We run no risk of contradiction when we affirm that nothing at the command of mere natural law, or of mere material force, could produce it." He knows, then, what of law and of material force universal nature commands—nay, what it did and did not command at a certain past epoch; and, more, knows this so well as to "run no risk of contradiction" in affirming it! He proceeds, "No mere natural forces [mere!], however gigantic and powerful, could break up all the fountains of the great deep, and open the windows of heaven: consequently, these events must be deemed miraculous," &c. Why is it that no Englishman of this generation seems ever to touch either of these questions, what is natural, and what is miraculous, without deeming that "consequently" the other is called up? What is their connection? We never could see more than between the questions whether a writing is true and whether the ink is good. Mr. Lucas goes on, "It is not the gentle whisper of quiet, nor the louder utterance of agitated, nature, but the thunder-voice of Almighty God which speaks in it." (Elijah, then, greatly erred, it seems, in his estimates of what was in the wind, earthquake, and still small voice). But if some things are done by "agitated nature," and others are beyond her power, and yet done, how many Creators or Lords have we? Evidently two, according to Mr. Lucas, a scientist who, like Daubeny, is up to the Faradayan standard, having apprehension of "the naturally possible and impossible."

This ditheism, and the said knowledge or faculty, though doubtless extant long ago, our reading traces no further back than Dr. Newman's "Essay on Miracles," published about 1830, or fifteen years before his change of religion. He makes it one "criterion" of a miracle to have no physical cause. The second of his classes of doubtful ones is "(2.) *Those which from suspicious circumstances attending them may not unfairly be referred to an unknown physical cause.*" Now, granting for the sake of argument, that it is *de fide* that some events happen with no physical cause, how are we to distinguish these? A most important task, because they are claimed as the miraculous credentials of various opposed creeds; and any physical cause, known or unknown, according to Dr. Newman, vitiates their claim. Whoever is to apply this criterion plainly needs, no less than the very requirement of Faraday, the very attainment of the above authors—an exhaustive knowledge of the universe and its contents. This is only possible by inspiration, as Dr. Newman would doubtless allow; and as high a degree thereof as ever was ascribed to any; for, surely, to know what is in nature would be a gift nowise inferior to His who, we are told, "knew what was in man." But no less a faculty does Dr. Newman make necessary to any and every learner who will know whether to regard a given fact as miraculous; though the sole use of miracle is to attest to him another's occasional and limited inspiration. What it is to prove is the inspiration of certain words; but to find whether it is any proof, you must first have inspiration unlimited.

Locke said, "To discourse of miracles, without defining what one means by the word" (which is all I find present writers doing) "is to make a show, but in effect to talk of nothing." As his definition does not quite satisfy us, we would define a miracle to be "a predicted occurrence, so improbable when predicted, that when accomplished it convinces men of a superhuman[*] presence." The time between prediction and verification may be half a minute, or fifty centuries; it may be "Peace, be still," or "They shall afflict them 400 years,"[†] or "Be thou clean," or "Go and wash in Jordan seven times;" but prediction there must be. Voltaire alone, that we are aware, points this out, that prediction is the prime essential. Without it there is no proper miracle, for all value lies in the event's relation to some antecedent utterance—not quite always in its verification, but, occasionally, when it is a king's, in its falsification: as when Nebuchadnezzar's prediction that he would burn the three Jews was falsified; or that of the Arian powers that they would instal Arius; or that of Julian that he would restore the Jews their temple.

Now to take a notorious case or two: If Peter made the prediction ascribed to him in Acts, v., 9, and Sapphira fell as stated (for we would no more rank her husband's death among miracles than the liar's recorded in Devizes market-place, since it was not predicted); or if the prediction in Matt., xvii., 27, was made and verified as the story implies;* either of these, we may presume, would be held as thorough miracles as any on record or tradition. But where, in either of them, is there room to insert anything without physical cause, or to make a breach of continuity? Would Dr. Newman say the act of the fish picking up a shining coin was unnatural; or less natural at one time, the moment before being caught, than at any other time? Would Mr. Lucas "run no risk of contradiction in affirming that nothing at the command of mere natural law could," at that time, cause apoplexy in Sapphira? and, "consequently, these events must be deemed miraculous." What have the question of miraculousness and that of naturalness to do with each other?

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[*] "Superhuman," or superkingly, does not of course imply "divine;" but Locke showed that when a miracle is set forth as divine, nothing can be simpler than the test of this claim. It will be divine if carrying "the marks of a greater power than appears in opposition to it." Professor Tyndall says he is asked to infer, from Aaron's rod or snake being larger than those of Jannes and Jambres, that these men were "not good." On the contrary, it is nowhere implied that they were less good than Moses. As far as appears, they faultlessly performed their duty, a most important one, similar to that on which the late emperor sent Houdin to Algeria, and for which we have here daily more pressing need. Houdin, by outdoing the Arab jugglers, arrested their mischievous authority. Pharaoh's magicians, tried their thaums (not juggling, apparently, but spirit sorceries), and made to their master an honest report, that, if credited, would have saved him and his army. From the snake experiments, as well as later, they logically inferred, "This is the finger of a god," or, rather, of the Supreme. If Aaron's serpent swallows ours, and we cannot produce one to swallow Aaron's, it is safe to infer that he is right. There can be no power greater than Aaron's God; because the Supreme (if there be any) would not allow an advantage over himself to be claimed and shown. This would be abdicating, and he would no longer be supreme. That "as Jannes and Jambres withstood Moses," so did certain bad men resist truth, nowise implies the former were bad. What they did, we maintain, ought always to be done in like cases.

[†] Longer periods might be instanced by travelling out of the legends in every child's hands. *E.g.*, Sir Isaac Newton deduced from Rev. xii., 6, that the corporate holders, in his day, of the ruins of ancient Rome, would hold possession thereof altogether 1260 years. He did not undertake to ascertain or state exactly when this possession had begun; but it is easily found, in Baronius, &c., that their first holding any of those buildings (namely, the only one in Europe that, "prepared" in antiquity, continues unruined and in use) dated from bequest of Phocas, who was deposed and killed in Sept.-Oct., 610. Moreover, whenever this class of facts come to be examined, it will be found that every date-prediction in the Old Testament has been verified, and, if observed, would have ended religious strife; and that the very longest, extending to 2300 years, had its consummation in this, our generation, not merely to the year, but the month and day.

Dr. Newman repeated, in his "Apologia," this paradoxical distinction between the "miraculous" and the "providential," and, on further inquiry, assured the present writer that "special providences are one kind of Divine works, and miracles are another." But on being asked for some notion of the difference, he was silent; and we believe that any number of divines or philosophers may be challenged in vain ever to make out a more real or objective distinction here than if he had said, "Stars near enough to have a detected parallax are one kind of Divine works, and those beyond present parallax-measuring are another kind." Whether instruments exist that have detected a star's parallax or not, is precisely and merely such a difference as whether the physical modus of an occurrence, say, of the fish getting the coin into its mouth, or of the great deep being broken up, and mankind swept off "in the day Noë entered the ark," is or is not satisfactorily clear to Mr. A. or B., to Daubeny or Lucas. The difference, then, between miracle and non-miracle would be purely subjective, and different for any two men existing, or that ever will exist. Thus, to Mr. Lucas, who finds from Geology that the deluge happened, but "knows" the universe to contain no "mere natural law" that could effect it, this event would be a miracle; while to us, who can find in no part of either its legend or relics the smallest departure from the laws even now known of the visible part of nature, and are driven to credit such legend by its minute correspondence in detail with all the latest discoveries in nature, it would be *no* miracle!

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* The passage is one of those most needing re-translation. "The takers of [temple]-shillings came to Peter, and said, Does not your master pay the [temple]-shillings? He saith, Yes. And as he entered the house, Jesus anticipated him, saying, What thinkest thou, Simon? From which do the kings of the earth take tax or toll? From their own sons, or from strangers? And when he said [*Vat.* and *Sin.* MSS.] From strangers, Jesus said to him, In that case the sons are free. But lest we make these men stumble, go thou to the lake, cast hook, and the first fish rising do thou take, and having opened the mouth thereof, thou wilt find a florin, which take and give to them for me and for thee." Definite coins ought by no means to be rendered "a piece" or "pieces," and the monetary terms used in translating the New Testament are most important, as influencing future language. The δηναριος, being a day's wage, ought to be rendered a *dollar*, as long as our coinage has no term better than the ambiguous and most barbarous "crown" and "half-crown." Lacking also any term like *talents* (for want of which we have such slang as "ponies" and "monkeys") this has to go untranslated. But μνας might be *purses*; στατηρ and δραχμή should be *florin*; and δίδραχμα, *shillings*; ασσάριον, a *groat*; κοδράντης, a *penny*; and λεπτά δύο ὁ εστι κοδράντης, "two *obols*, which make a penny," giving this decent word a chance of superseding our wretched "halfpenny."

In the stifling dust raised around all these matters since Dr. Newman's paradox, Professor Tyndall has made the true remark that there can be no prayer-granting without miracle, or, rather, the miraculous element. If unseasonable weather changes, after prayer for "seasonable" weather (the only prayer thereon ever sanctioned by the church), into seasonable, this implies the miraculous, but no more of the unphysical than Peter's fish. Dr. Tyndall, however, first ignoring the church's important adjective, compared this to a prayer that an eclipse might be delayed; as if such delay would be a thing "seasonable." He then lays down as "science" the gratuitous paradox that winds and clouds of to-morrow may be, like the planetary motions, pre-determined by only brute cosmic forces; which, if as true as it is demonstrably false, would not even then give the fixity he wants, as the planetary system itself is invaded at any moment by unknowable comets and meteors, and solar radiation hourly altered by storms of the photosphere. He requires, at the outset of his attack, all the present century's discoveries to be ignored. But let us grant him a solar system as simple as mediæval ignorance ever fancied; this would not help him. Yonder is a gardener, who may dig twenty more spadefuls before dinner, or perhaps only nineteen. Is Dr. Tyndall prepared to prove that whether they shall be twenty or nineteen is already as determined, by laws of brute matter, as the next transit of Venus? If not, he should have warned readers that the whole prayer argument was a mere *jeu d'esprit*, hanging on the assumption of this extreme necessarianism. Relax one stitch thereof, and the whole fabric falls, thus:—If there be any uncertainty about that twentieth spadeful, on this may depend whether a slug is turned up or not; on the slug may depend a young swallow's dinner who is feeble, and on this may depend whether he shall follow his colony, and reach Africa; but on this fledgling's arrival or non-arrival may depend whether a certain insect shall serve him for supper, or be left to lay a million eggs, which, in that case, will next month be each a locust laying a million more; and on this billion of locusts and their progeny may depend whether at Christmas all Ashantee and three Senegambias of forest shall be green as Eden or a leafless wilderness, and its mean temperature 100° or only 70°; and on whether such an area be the hottest or coolest portion of the planet's intertropical lands, may well depend, by Dr. Tyndall's own showing, the winds and drought or wet of a season, over half Europe or the whole. It behoved him, then, to be quite sure about that gardener's last spadeful, and all such causes, which yet he wholly leaves out of account! The weather of large districts may as plainly be still more quickly affected by events that acts of man or beast unconsciously bring about—as forest fires; avalanches that a goat may set rolling; dykes burst, and Zuyder Zees refilled for ages by the burrowing of a rat; shoals of herrings or of whales that by turning right or left may make a month's difference in the break-up and drifting to us of half a year's polar ice. Here we confine ourselves to visible nature and known forces. Let the insane assumption be granted that there is no invisible nature, nor aught unknown, and even so, He that owns and actuates the cattle on a thousand hills, might thus plainly, by only one of their hoofs, make the winds his ministers, and flames of fire his messengers.

The flood of paradox thus accumulating from the crudities of teachers of the most different schools makes all we have said, and more definition, necessary for protection, ere one can touch matters even distantly bearing on these. The writer hopes, therefore, he will be understood to have no knowledge as to the limits of the "naturally possible and impossible;" and lacking this, or any ground for the conceit of two such differentiated powers as "nature and God," he can only understand by "nature" the course of whatever has happened; and thus can make no distinction between saying a thing happened, or that God did it, and saying it is natural. "If the dead rise not, then is Christ not risen," and he who thus wrote, we suppose, would have added, if relevant, "and if the living are never born of virgins, then was Christ not so." Before a man can know this to be never natural, he must know that neither was Christ so, nor Adam, nor any pre-adamite man, mammal, or ascidian; that no virgin ever bore the head or progenitor of a new race, to be superior to her ancestral one. Now, since Aristotle's eternity of generations is by general consent now exploded, it seems, on the whole, more probable that this thing may have sometimes happened; even as many times as the earth contains distinct organic species. But if only once; or if but one planet has once been overtaken by steam enough to deluge it totally in one day; or if a bodily levitation, like those of Mr. Home, testified by the editor of this journal, by Lord Lindsay, and many others, has only once occurred to any man; then each of these occurrences is sometimes natural. Under what conditions, we may never be able the least to define, but whatever happens we must call natural, whether the naturalness be clear to few or many, to all or none of us. We can only hold it to be within the regular course or evolution of the Eternal Evolver, "with whom is no variableness nor shadow of turning," and whose machinery more than one ancient termed "His wheels" (Ezek., i., 16; Dan., vii., 9); the continuity of which, through miracle and non-miracle alike, the former seer surely not obscurely intimates. "Whithersoever the spirit was to go, they went, and turned not." No reversal or instant of interruption in the Evolver's laws. "When the living creatures went, the wheels went by them." "When those stood, these stood;"—"for the spirit of the living creature was in the wheels,"—not away, or distinct from the mechanism. And though wheel be within wheel, and "as for their circles, they were so high that they were dreadful," yea, worshipped; and in these days, no less than Ezekiel's, it has been "cried unto them in my hearing, O Wheel;" yet is this twice repeated that they are "full of eyes," and that the living spirit is not distinct from, but is "in the wheels."

Neither spiritualists nor admitters of historical miracle, then, believe, as they are taxed with doing, any interruption of natural law. We as fully hold the continuity and eternity of evolution and its laws as Sir William Grove does. But to the false charge of our holding this superstition, there is added the boast that modern practical science has abandoned the same, and insists on absolute continuity. This is no truer than the above, as an example from those making most practical claim to science will show. While the Sydenham Crystal Palace was building, in August, 1853, a scaffolding fell and killed some men, so that an inquest had to be held. The witnesses and experts, including three first-rate engineers, named Vignoles, Crampton, and Fox, agreed that the fall was "one of those events that cannot be accounted for;" that neither the materials nor plan of construction could be better (*Builder*, 1853, p. 546); the two former that both were such as they would repeat identically, and Crampton advised that this should be done, "believing it to be perfectly safe,"—safe by physical law, though in fact it had fallen. Neither our engineers nor coroners' courts, then, object to miracles in Dr. Newman's sense—events without physical cause, or breaches of physical law. They will on occasion, on what they consider "dignus vindice nodus," admit as readily as any mediæval monk, that "Deus intersit" in this capricious manner. But as Paul said that if the Sadducees were right, he and his fellows must be "false witnesses of God," in testifying that he raised up a man from death, "whom he raised not up if so be that the dead rise not;" we must admit that, similarly, if the view of continuity common to St. Paul, Grove, Tyndall, and ourselves be sound, these engineers are just such witnesses, in swearing that, to overthrow the scaffolding, He interrupted natural law, which He did not interrupt if (as we hold) it is continuous.

Events that we hold to be, like all events, natural and "in the wheels," but which are not explicable without the volition of unseen beings, and have so been taken to attest the presence of an invisible population, require some distinctive name. Any that were clearly predicted would of course, by my definition, be miracles; but when they are not predicted, this definition excludes them, and I would suggest the non-scriptural but classic and patristic term *thaums*. In every historical age of the most civilised countries, these have been as well attested as any terrestrial facts, not reproducible at will, can be attested; and during the centuries, before and since the Reformation, that the frightful superstitions as to the crime of witchcraft held sway, plenty of such facts were always sufficiently testified to induce English judges and juries, and afterwards American ones, to consign hundreds of unfortunate, harmless women to death. One phenomenon always then held to fix this crime—and which, if proved in court, would cost the subject his or her life—was bodily levitation; in which some force was seen to work, in Archbishop Trench's words, "as an opposing force to the attraction of the earth," and also "to overbear it." The thing is testified now, of Mr. Home, a Scotchman, the American Davenports, when children, the eleven cases already recorded, as witnessed by the Editor of this Journal, and probably of more individuals now living, and by a greater mass of respectable testimony than it ever was in any single past age; though there were examples in every age of which civilised records remain. Now the most striking point is the close correspondence of minor details in the old accounts with those noted by modern witnesses, who evidently never saw nor received any tradition of those accounts, and, indeed, are generally under the error that the whole is as new a discovery of this age as galvanism or photography.

As Newton is held to have proved that gravitation and inertia in every mass are proportional, we might expect that whatever overbears the former would be equally capable of neutralising the latter; and, in fact, the elder records hardly speak of visible suspensions like those of Mr. Home, but mainly of sudden unseen transfers of the person to a distance; like that alleged of Dr. Monck last year, from his own residence at Bristol to the garden of his friend, Mr. Young, at Swindon; or the earlier but better attested one of Mrs. Guppy, from her house at Holloway to a circle of her friends assembled at No. 61, Lamb's Conduit Street; or, a few months ago, that of Mr. Henderson, a well-known photographer of London, for a smaller distance, but attested by eighteen persons besides himself—the nine assembled with him at Mr. Guppy's, and the whole Stokes family, at Highbury, where he was unexpectedly found. It is easy to see that two or three such transfers occurring to one man, as Abaris the Scythian, in the time of Pythagoras, could not fail to procure him the surname of "*Æthrobat*," or air-walker; and in the next age the story that Apollo, of whom he was a priest, had bestowed on him a golden arrow, whereby to be conveyed wherever he desired. But this most natural error, that the adepts can be levitated at will, and in what direction they please, does not tinge the older, yet more sober, record of our earliest historic æthrobat, him of the Old Testament. "And behold," expostulates the courtier to whom Elijah (vainly sought for three years) had first reappeared, "thou sayest, Go, tell thy lord, Behold, Elijah is here; and it shall come to pass, as soon as I am gone from thee, that the spirit of Yahveh shall carry thee whither I know not; and so when I come and tell Ahab, and he cannot find thee, he shall slay me." Then he recounts his piety (1 Kings, xviii., 11), "And now thou sayest, Go, tell thy lord, Behold, Elijah is here; and he shall slay me." He dares not go till the prophet has sworn, "I will surely show myself to him this day." Like all our modern æthrobats, though he cannot will nor direct his levitations, he can prevent them. The allusive and matter-of-course way that their general fact here comes in, so that, but for this and one mention after his final disappearance, we should not guess the phenomenon to have occurred in all Hebrew history, is inimitable, and makes it far stronger than if particular cases had been described. Not even was it introduced by any such note as that respecting young Samson, "And the spirit of the Lord began to move him at times in the camp." It seems assumed that readers of this brief abstract from the annals will no more need telling that Elijah was frequently air-borne, than to be told what country the Pharaoh ruled; or than the sons of the prophets needed to explain when, after his ascension, they said to his successor (2 Kings, xii., 16), "Behold now, there be with us fifty strong men; let them go, we pray thee, and seek thy master; lest, peradventure, the spirit of Yahveh hath taken him up, and cast him upon some mountain, or into some valley. And he said, Ye shall not send. And when they urged him till he was ashamed, he said, Send. They sent therefore fifty men; and they sought three days, but found him not. And . . . he said unto them, Did I not say unto you, Go not?"

About three centuries after this, but in Europe, and not yet in quite such broad historic daylight as in Ahab's Israel, we find the pair of levitants, Abaris and Pythagoras. If it were still mythic twilight, all or the main share of this and any other marvellous feature, would be heaped upon the crown of the great seer and martyr, the greatest European of his age, or perhaps of any age, the founder of the most civilised religion of the next thousand years, whose votaries ceased to quote him by name, but only as "*He*," and maintained that "Three kinds of being are biped—birds, men, and our master." But the habitual air-walking is ascribed only to his humble friend Abaris, of whom nothing else is known; and but one single levitation to the great sage. According to all his three biographers, it was universally held that once he had on the same day addressed a class of his disciples in the city of Metapont (near the modern Taranto), and another circle in Taormina, at the foot of Etna. As in every modern case, we observe, it is only into the company of friends, either recorded to be at that moment speaking of him, or very presumably having him in mind, that the levitant is carried. That Pythagoras was a born thaumaturge, or first-rate "medium," as it is now called, appears, apart from all legend, by the most remembered of his peculiar dicta, namely, that "All things whatever are to be hoped for, because all are possible to the Gods." This is evidently identical with Christ's most enigmatical doctrine of receiving "whatsoever ye ask believing;" and is a sentiment that, true or false, could never enter the head of a person not familiar with thaums, and these of manifold kinds and sorts. Moreover, the followings gathered by this old man, as well as by the short public career of Christ, could not be accounted for by mere eloquence, however great. And surely it needed a prophet, in the fullest sense, to teach, 2000 years before any other European would believe, that the earth is a planet, and turns on its axis; as well as to develop that psychologic and religious creed, of plural incarnations of the same soul at long intervals, and suspension of memory during each earthly life, but restoration after it, which, though the creed for the last twenty centuries of a majority of our race, is barely now penetrating Europe: and of which, by the way, we may remark that if Christians oppose it, they have to make their own Master ("whose goings forth have been from of old, from everlasting"), a mendacious witness, alike in saying Abraham had seen his day and rejoiced to see it; or that Nicodemus and similar men, must be born again before they could even see his kingdom; or repeatedly affirming his young cousin John to be Elias, when it is plain that the son of Elizabeth could not be Elias if there be no "resurrection of (or in) the flesh."

Passing over apocryphal stories, chronology brings us next to the Author of Christianity and his opponent; for all the accounts we have of the most public prodigy—unless that of feeding the 5000 were more so—and apparently the first quite public one wherein Jesus figured, represent this wonder as not his spontaneous act, if his at all, but provoked, or rather wrought, by his adversary, "the devil" of the first and third gospels; who, according to the Jewish legends, was the same Judas who afterwards compassed his capture and death. Among the six legends extant, four coming to us by tradition of his church, and two by that of his enemies, only one, the gospel of John—a treatise professedly supplementary to others—omits this event; and in that very document, out of three times that Jesus mentions a Διαβολος, in the first he refers simply to the said man; as the writer himself informs us after recording the speech, "Have not I chosen you twelve? and one of you is Διαβολος." In the other gospels it is used but thrice by Him, always in parables; and nine times by the narrators, solely in this story, where it is an alternative term for "tempter," though Mark, who gives no detail thereof, uses the Hebrew "Satan," and Διαβολος does not occur in his gospel. It is a word, then, used by no narrator except in this story; in this by only two of them; and elsewhere by Jesus alone, either in mystical doctrine and parable, or, once out of three, as a name for Judas. From the gospels alone, the only natural conclusion respecting this "tempter," whether seen conveying Jesus about, or with him on "the pinnacle of the temple" (necessarily visible to multitudes), would seem to be, that he was some man well-known to the multitude; and this has been the view of those critics in the present age who, like Strauss and Rénan, have chosen to ignore the existence of any other ancient materials on this history than are in every child's hands. They hold that the priestly party deputed some subtle Pharisee to test and expose the new Prophet's claims, and the contests to which he drew him, first in the Jordan wilderness, and afterwards at the capital, are what the forty days' temptation denote. Now, according to the legend translated for us by Luther and Wagenseil, and which was certainly current among the Jews of the fifth century,* as soon as news of the movement excited by the Galilean wonder-worker reached the Jerusalem Sanhedrin, they consulted, and agreed that the miracles proved their author to have obtained access by magical arts to the adytum of the temple, and stolen from thence the knowledge of the right utterance of the mightiest divine name, which was well-known to be recorded on a certain stone, and the pronouncer of which might effect any prodigy whatever. Hence the precautions taken always for its concealment, since David had found this stone† at his first preparing the foundations; and there was now danger of the whole nation, or even world, being perverted, by the abuse of this tremendous spell. The only chance of remedy for the awful calamity, they agreed, was if some orthodox rabbi could, by similar trespass, obtain the same power, and then display it before the increasing multitudes now following the Nazarene, to convince them that such marvels were no credentials for the divinity he claimed. At this point, Judas, the hero of these legends, and whom they place in a widely different social rank from what the evangelists seem to imply, for he is himself a member of the Sanhedrin, comes forward. He is an expert magician (or what would now be called a highly-developed "physical medium"), and he would undertake this patriotic task, were it not for the sin involved. They immediately all offer to relieve him of the sin; for the idea pervades these Hebrew tales, that any guilt whatever can be transferred to a voluntary substitute. "Upon us be all the guilt!" cry the whole council, if Judas will but take the trouble, dangers, and glory of the enterprise. The means are then described by which he penetrates the holy-of-holies, and gets out again, with the magically guarded secret. He proceeds to the Galilean crowd, and repeats all the miracles of their Master, decidedly more extravagant as here told than in any of the gospels; for each of the contending thaumaturgi invites the people to bring him cripples or invalids of any kind, and he will heal them; lepers, and he will cleanse; blind, and he will give them sight; or corpses, and he will revive them. And to try the last, they in each case open an unknown tomb, and bring nothing but dry bones; which have to be endowed first with flesh and then with life, as in Ezekiel's vision. The contest being a drawn one, the rivals now repair to Jerusalem, where, almost in the words of the fourth gospel, Jesus is made to say: "Nunc autem ascendam ad Patrem meum cælestem, et sedebo ad dextram ejus; idque oculis vestris intuebimini. Tu verò, Juda, illuc non pertinges. Continuò enuntiat Jesus Nomen immensum, venitque ventus et eum stitit inter cœlum et terram. Nihil moratus Juda et ipse Nomen eloquitur, atque hunc quoque ventus inter cœlum et terram suspendit. Sicque ambo per aëreas plagas circumvolitabant. Stupebant ista summoperè omnes intuentes. Juda autem, prolato rursùs Nomine, Jesum invadit, in terram illum deturbaturus: atque sic invicem colluctabantur." Now have we not here, and in the gospel accounts of the temptation on the summit (*το πτερυγιον*) of the Temple, a degree of coincidence in two opposite parties' traditions, inexplicable unless both recorded a real event? In each, a preeminent adversary provokes a contest with

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* I follow Wagenseil's translation in vol. ii. of his "Tela Ignea Satanæ," Altdorf: 1681. That this document has undergone no essential change since the fifth century appears from its ending with the story of Simeon Stylites, whom it confounds with Simon Peter, and regards as the highest authority then among Christians. But the reverence of Christendom for this fakeer could not continue such as to convey this notion, even to outsiders like the Jews, much longer than poor Simeon's own life, which ended in 459. This legend must rank then, for date, with our gospels, no MS. of which can be traced with certainty above that century.

† The stone, it is insisted, was untouched by tools, yet having "insculptum nomen Dei ineffabile." The tradition evidently grew from certain prophetic texts, especially Zech., iii., 9; having some relation also to Isa., xxviii., 16, and Ps., cxviii., 22, the two verses most quoted (ten times) in the New Testament. The idea of healings and other wonders to be wrought by the utterance of a name or spell, was also plainly prevalent in New Testament times:—Acts, iii., 16; iv., 10, 29; v., 40; and, especially, xix., 13.

Jesus, first near the upper Jordan (where both make His movement to have commenced) and afterward at Jerusalem. In each, this results in levitations and aërial journeys of both together, and they are simultaneously seen over the Temple. In each, the adversary's aim is a precipitation of Jesus from a great height into the crowds of the holy city. In each, he fails ;* and we may add that, in the only account naming and identifying him, he is the same man who, in the speech ascribed to Peter (Acts, i., 18) is stated to have incurred, three years later, the exact fate he here plans for his victim ; and, further, that he is the only man to whom is anywhere appropriated the term Διαβολος, which, in narratives, is peculiar to the opponent who "taketh" and "setteth" Jesus in these strange positions. Surely, on the whole, we must regard this devil as a man—the tool employed (doubtless by the great real Satan) to play a similar part towards this "last man-Adam" to that borne toward his and our greatest ancestor, the Messiah of Eden, by the villain "*Ha-nachash*," remembered only by the name his punishment earned ; "the crawler," doomed on his belly to go, and dust to eat with all his food, all the remaining days of that life. And as the other application made of this term Διαβολος is to that father of Pharisees and "murderer from the beginning," may we not conclude that Jesus, whose view of resurrection was so plainly Pythagorean, implied these two to be incarnations of the very same "wicked one ;" and probably Doeg, against whom the

* The above story, whose end is untranslatable, makes this, like all the other miracle contests, a drawn one ; neither magician displaying any advantage, like Aaron's, over the other ; and any moral aspect, such as the gospels give to the struggle, being absent, as there is no moral element in these legends. In the ancient "Toldoth Jeshu" quoted, he merely works wonders, chiefly of healing, and maintains that he is not of illegitimate birth, as the Sanhedrin insist, but is the Creator of heaven and earth, "Deus, et quidem Filius Dei," and requires all to obey him as such ; the crowd acknowledging him purely on the strength of his miracles. Hence a reader is more reminded of the fourth gospel than of the others, wherein such claims are subordinate to moral parables and precepts. In this document, however, his conduct has no more spot than in any of them,—Mr. Voysey would say it has less. It is far otherwise with the mediæval "Toldoth Jeshu Natzri," published by Huldrich, in which he is made atrocious, and murders his father Joseph. Both documents agree with the gospels, against present "criticism," in placing his birth at Bethlehem. They also startlingly dissolve some of the seemingly most incompatible differences in Matthew and Luke. Thus, they both make Mary a Bethlehemite, but, one of them, Joseph a Nazarene, which would most naturally reconcile the annunciation stories, if Mary was at that time on a visit to her future husband's town. Again, if Judas (whom they agree with the fourth gospel in making a spy deputed by the rulers from the first, always feigning discipleship, merely to effect the capture intended throughout) was, as they both make him, a member of the Sanhedrin, the purchase of the field Aceldama might be indifferently called his act or that body's.

maledictory Psalms were uttered, an intermediate birth of the same? And if so, may not the natural wishes for such a wretched soul's amendment, expressed by many before Burns, have long ago received some realisation, at least if Matthew's story of his remorse and suicide be held probable; and an amelioration have commenced, if not earlier, at any rate with those results of his three years' companionship with Him who is declared to be "the Saviour of all men, especially of them that believe?"

The Hebrew accounts also present, immediately after this, an equally close coincidence with the Christian ones on the next most public display of miracles, and the only ones, before his death, related so as to involve levitation. Those of one day and night are thus concentrated. Returning to the Jordan, they say, he caused two millstones to float, and standing or sitting thereon, he caught fish, and distributed to his crowd of followers on the banks. The later "Toldoth" has but one millstone, and "the sea" instead of the river. Now the evangelists all place the feeding of the five thousand with fish, on a bank overlooking the Lake of Galilee; and the miraculous walking, on the following night, upon the same lake; which is a mere expansion of the Jordan, but is most frequently called by them "the sea." Moreover, to avoid the crowd's taking him "by force, to make him a king," they tell us, immediately before one miraculous fishing (Luke, v., 3) he addressed from one of two boats the multitude on the shore. The "millstone" has evidently come from a figure used in his own prediction of the remorse of his betrayer; and thus there is not one feature or word of this grotesque medley, not traceable to a parallel in the most prominent incidents of the gospels.

Soon after this, and the Baptist's death, we read of His holding a very private meeting, with only the three most developed of his eleven chosen disciples, and while he was "transfigured" before them (a phenomenon lately paralleled, we are told, by those who observe modern media), two human forms conversed with him, "which were Moses and Elias." In the similar accounts now given us, of the re-embodiments at New York or in London, a slight atmospheric change causes the forms to announce that they must disappear, and one has complained of the "density of the air" making her embodiment difficult. Now Jesus chose for the above transfiguration "a high mountain." Has any reason for this choice been ever suggested; or for his habit of ascending mountains to pray?

For a few weeks after his death, his own form was again repeatedly materialised; most notably, according to Matthew, on "a mountain" (which may probably be the occasion when Paul says five hundred were present) but otherwise, as we read, in no wider circle than "the eleven;" exactly as the visitors to the Eddy family in Vermont now describe their (the visitor's) dead and buried relatives to reappear and converse. Like these He invited handling, and pointed out that "a spirit hath not flesh and bones as ye perceive me to have;" like these He ate and drank; and like these vanished. Two of these memorable visits were terminated by visible ascensions into heaven[*]—one from Bethany, in the evening of the first Easter Day (Luke, xxiv., 50), and another from Mount Olivet some weeks later (Acts, i., 9-12). Disappearances of such tangible forms by ascension, though within doors, are recently testified by Mr. Robert Dale Owen and others.

As the gospels represent spirit possession to have been a most prevalent affliction at that time, so do they indicate the levitation of the possessed; as in English and American witch trials, two centuries ago and later.—Mark, ix., 17-26—A demon that "whithersoever he *took*" (καταλαβη) his victim, tore and rent him, often also "*cast* him into the fire or into the water." Luke, ix., 39—"Lo, a spirit *taketh* him;" 42, "The demon *threw* him down." The phrases are as distinct from any used of a lunatic throwing *himself* down, or injuring himself (Mark, v., 5) as in the English witch levitations. The phenomenon was more associated with bad than good spirits, being only once related of Christ between his temptation and death; and only on Peter's request does he grant to him also to come unto him on the water. We never again read of it among the wonders attending any apostle; but one of their first seven deacons, Philip, seems to have been congenitally a psychic excelling them all, "for unclean spirits, crying with loud voice, came out of many that were possessed" (viii., 7), and, as an instance of hereditary mediumship, "the same man had four daughters, virgins, which did prophesy" (xxi. 8). He accordingly affords the last Scriptural case of an æthrobat; for after his baptism of the destined founder of African

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[*] In an appendix to the "Boyle Lectures" for 1708, Whiston proved that the scriptural heaven of angels, and of the just, can be no other than the upper strata of our atmosphere; and that such is the abode the writers assign to Christ ever since his first posthumous appearance to Mary Magdalen, saying "Touch me not, for I have not yet ascended to my Father." As he appeared at least twice more during that day, and allowed himself to be touched, we must infer that he then *had* ascended; and, in short, ascended as often as he vanished.

Christianity (viii., 33), "the spirit of the Lord caught away Philip, that the eunuch saw him no more, and he went on his way rejoicing: but Philip *was found* at Azotus;" this phrase, instead of "found himself," seeming to imply that he alighted among friends, as in most other recorded cases of the kind.

Whether we read Christian, Jewish, or Pagan accounts, the first Christian century abounds in thaums beyond any other. False Christs were to arise, and to "show great signs and wonders." The most typical instance of these doubtless was Philip's original rival, Simon Magus, the mere beginning of whose career the Acts do but touch. For a whole generation he travelled and proclaimed himself both the Hebrew Messiah, and an incarnation of each people's chief deity; basing all his claims on a series of prodigies which no contemporary, friend or foe, seems to have ever denied. In the "Recognitions," a work soon after ascribed to Clement, and certainly current in the next century, his translations through the air figure among these; and another Clementine (or, as now held, pseudo-Clementine) book, the "Apostolic Canons or Constitutions," contains the professedly earliest account of his end at Rome, by a public display of this faculty, in defiance of one or two Christian apostles; at whose prayer that he might fall—but not fatally—he is related to have so fallen as to break both legs, and then, from shame, to have committed suicide. If one of his opponents was Paul, and the other unnamed, nothing was more natural than for a dramatic instinct to fix on his first rebuker, Peter, as having thus re-encountered him; and this may have originated the whole momentous legend that brings Peter to Rome, the first traces of which appear in the Patristic repetitions of this adventure.

An equally attested æthrobat of that century, whose long life was held indeed nearly to fill it, was Apollonius of Tyana, the most famous and closest of all imitators of Pythagoras. His life, by Philostratus, a work of some bulk, and written, Dr. Newman says, with elegance, has the rare advantages of being certainly drawn up within a century of his death, and from all the materials that a literary empress, the wife of Severus, could collect;—the philosopher's own writings, a diary of his favourite and constant companion, Damis, memoirs by his chief earlier acquaintance, and the archives of the numerous cities that had received and honoured him. A century later, this book was made the basis of an attack on Christianity, answered by Eusebius, and now lost; but there is no evidence of Philostratus himself having written with any view, as Dr. Newman says, "of rivalling" the Christian marvels. None of his translators (including Berwick, a clergyman) have believed they detected any such aim, and it seems clear that this courtly professional bookmaker could have seen no documents of the despised sect, or some trace of allusion would be found. All his marvels imitate, on the contrary, tales current of Pythagoras; and most are either childish, objectless, or such as elude any real test—witch-finding, communicating by whispers with birds and animals; when imprisoned with Damis, drawing his leg out of the fetter, and then putting it in again, &c. But there are two that Dr. Newman thinks resemble Scripture miracles in forcing themselves into the history "as a component part of the narrative"—the first being the alleged cause of his acquittal when on trial before Nero, for the crime the latter had invented, of philosophising in Rome. His accuser, Tigellinus, coming to unroll the bill of indictment, found only a blank paper (which may have been a miracle or may not). The other is the latest and most detailed point of his whole public career. He surrendered similarly before Domitian, who had revived the edict banishing philosophers (among whom the apostle John seems to have been reckoned) not only from Rome, but from the Continent. The trial attracted great notice, the grandest tribunal being used, and decorated as for a festival; but it ended sooner than was expected, by the emperor acquitting him, only adding that he must be detained for a private interview that he desired after the day's business. The aged prisoner, with thanks, briefly declined the honour, unless the emperor could detain both his soul and body. The former no human power could; no, nor, unless the gods willed it, even his body. He added a line of Homer, wherein Apollo says, "you cannot put me to death, for I am not liable thereto;" and on these words, vanished from the court; on the same afternoon as suddenly surprising his friends Damis and Demetrius, while talking of him in a grotto at Puteoli. One other such levitation occurs many years earlier, when at Smyrna he was crowded by sick persons, and by deputations inviting him to various cities. The Ephesians sent begging him to stay a pestilence; whereon, thinks his biographer, he designed to imitate his great master's passage from Italy into Sicily, for on replying "Yes; let us go at once," immediately he was at Ephesus. Dr. Newman, who does not mention this prodigy, thinks its sequel, the staying of the plague, "the best authenticated of his professed miracles, being attested by the erecting of a statue to him in consequence." It was also a count in his indictment for magic before Domitian. The second and last levitation, from Rome to Puteoli, and its effects in court, are described with much apparent truth to nature, but Philostratus goes into the supposed reasons, and a panegyric of his hero's wisdom, shown in the manner and timing of the marvel. Now he has to embody, as the chief piece extant from the hand of Apollonius, a very elaborate defence he had prepared for this occasion, and intended to have spoken by the waterclock; but not a word of which he really delivered, except the above line of Homer, wherewith it was to have ended. This glaring inconsistency strikes of course all commentators, and poor Philostratus, at his wit's end, seemingly despaired of glossing it over. It is created, however, solely by his gratuitous assumption that such thaums are the work of their subject. By all parallel accounts, from the case of Elijah to that of Mr. Home, they are so independent of his will, that we can no more suppose Apollonius to have known he was to be caught away, than do psychics of the present day. The inconsistency, then, disappears—nay, comes to tell strongly in the story's favour. On the whole, is it not better attested than any other marvellous one of its age? And will any Christian consider it less called for, less opportune, or less worthily ascribable to the Supreme Providence than most of those in his Testament? Can any say it would have occurred to better purpose at a trial of St. Paul or St. John? Supposing the account accurate, whatever intelligence directed the event so timed it as to force on a vast assembly the dogma that a man is no more liable to extinction of being than Homer's Apollo. And this in a world's capital where, for well-nigh two centuries, all belief in an after-life had, among the most educated, been extinct. In the senate of Cæsar's and Cicero's time, it was treated as a dream beneath serious notice. What could Christianity or any of its teachers do without this basis, which they rather assumed in their hearers than professed to prove? Paul could but appeal to his own veracity and apparent interests:—"If the dead rise not," we are false witnesses, or we are "of all men most miserable." A Sadducee or a modern Comtist would reply, "So you are." And in a society where such negation was held as a "positivism," and no facts overthrew it, what change could aught that we find in the New Testament have effected?

Iamblichus, in the next century (De Myst., Lib. III., c. 5), declared that one of the marks of obsession by spirits was, for the body "to appear elongated or thicker, or be borne aloft in the air."

In the century of the Church's triumph, at least one Christian and one heathen case of levitated persons are recorded. Sozomen relates after Hilarion, the founder of monachism in Palestine, that as four of his monks, whom he names, were returning to their convent of Bethelea, in the desert of Gaza, the youngest, but most esteemed, one Malchio, who soon afterwards left this life, suddenly vanished from their midst, and later in the journey reappeared ("Eccl. Hist.," Lib. VI., c. 32). The other case is an Egyptian prostitute, who came to Zosimas, an abbot, to beg his prayers and instruction in Christianity. As she was kneeling at his feet, he told her to turn and pray for herself and others. This he described her doing like Hannah, silently moving her lips:—"Juravit autem, sermonis sui testem appellans Deum, quod animadvertens longiùs protrahi orationem, oculos aliquantum à terrâ sustulit, viditque ipsam orare in altum sublatam, et in aëre suspensam, velut ad cubitum unum; quod cùm vidit, majori correptus metu, multùmque anxius, et omninò nihil proloqui audens, solùm intra se dicebat identidem, Domine miserere. Sic autem in terrâ jacens, scandalizari cœpit senex cogitando, ne fortè spiritus esset atque orationem simularet." Plainly, in the days of the British Solomon and the *Novum Organon*, this poor woman would, on any British ground, have made acquaintance with the halter or the stake. But Zosimas, after due probation, baptised her; and after the life of an exemplary nun, she became revered to this day as St. Mary Ægyptiaca; though nothing approaching miracle seems to have been ascribed to her as a Christian, or after this first interview ("Acta Sanctorum Aprilis," Vol. I., p. 79). Ecclesiastical miracles in general follow a distribution quite opposite to that of these phenomena. The darker and less historical the age, the more miracles, but the fewer of these phenomena. The testimonies to these, absent so far as we see in the ages from the fourth century to the ninth, increase in number, respectability, and accuracy, from the latter to the present day. Till the last two centuries, indeed, all persons known in Christendom to be subjects of levitation were probably either burnt or canonised, according to the ruling clerical view of their orthodoxy or the reverse. The following is an attempt to collect some of the chief examples not condemned, with the volume and page of the Bollandists' "Acta" where particulars may be found:—

Forty Levitated Persons, Canonised or Beatified.

Name, Country, and Condition.	Date of Life.	Acta Sanct.	Vol.	Pages.
Andrew Salus, Scythian Slave	880— 946	May	VI.	16*
Luke of Soterium, Greek Monk	890— 946	Feb.	II.	85
Stephen I., King of Hungary	978—1038	Sept.	I.	541
Ladislaus I., Ditto (his grandson)	1041—1096	June	V.	318
Christina, Flemish Nun	1150—1220	July	V.	656
St. Dominic, Italian Preacher	1170—1221	Aug.	I.	405, 573
Lutgard, Belgian Nun	1182—1246	June	III.	238
Agnes of Bohemia, Princess	1205—1281	March	I.	522
Humiliana of Florence, Widow	1219—1246	May	IV.	396
Jutta, Prussian Widow Hermit	1215—1264	May	VII.	606
St. Bonaventure, Italian Cardinal	1221—1274	July	III.	827
St. Thomas Aquinas, Italian Friar	1227—1274	March	I.	670-1
Ambrose Sansedonius, Itln. Priest	1220—1287	March	III.	192
Peter Armengol, Spanish Priest	1238—1304	Sept.	I.	334
St. Albert, Sicilian Priest	1240—1306	Aug.	II.	236
Princess Margaret of Hungary	1242—1270	Jan.	II.	904
Robert of Salentum, Italian Abbot	1273—1341	July	IV.	503
Agnes of Mt. Politian, Itln. Abbess	1274—1317	April	II.	794
Bartholus of Vado, Italian Hermit	1300	June	II.	1007
Princess Elizabeth of Hungary	1297—1338	May	II.	126
Catharine Columbina, Sp. Abbess	1387	July	VII.	352
St. Vincent Ferrer, Sp. Missionary	1359—1419	April	I.	497
Coleta of Ghent, Flemish Abbess	1381—1447	March	I.	559, 576
Jeremy of Panormo, Sicilian Friar	1381—1452	March	I.	297
St. Antonine, Archbp. of Florence	1389—1459	May	I.	335
St. Francis of Paola, Missionary	1440—1507	April	I.	117
Osanna of Mantua, Italian Nun	1450—1505	June	III.	703, 705
Bartholomew of Anghiera, Friar	1510	March	II.	665
Columba of Rieti, Italian Nun	1468—1501	May	V.	332*-4*, 360*
Thomas, Archbishop of Valencia	1487—1555	Sept.	V.	832, 969
St. Ignatius Loyola, Sp. Soldier	1491—1556	July	VII.	432
Peter of Alcantara, Spanish Friar	1499—1562	Oct.	VIII.	672, 673, 678
St. Philip Neri, Italian Friar	1515—1595	May	VI.	590
Salvator de Hortâ, Spanish Friar	1520—1567	March	II.	679-80
St. Luis Bertrand, Sp. Missionary	1526—1581	Oct.	V.	407, 483
St. Theresa, Spanish Abbess	1515—1582	Oct.	VII.	399
John à Cruce, Spanish Priest	1542—1591	Oct.	VII.	239
J. B. Piscator, Roman Professor	1586	June	IV.	976
Joseph of Cupertino, Italian Friar	1603—1663	Sept.	V.	1020-2
Bonaventure of Potenza, Itln. Friar	1651—1711	Oct.	XII.	154, 157-9

As the lives of all these are pretty fully recorded, we have the means of drawing several generalisations. It is plain that all displayed the qualities most distinctive of the present "spirit-mediums," and many were accompanied from childhood by some of the same phenomena, though I find nothing resembling the "raps." The hereditary nature of their gifts is shown by the Hungarian royal family producing five examples; and it is also notable, on this head, that out of forty there should not be one of British or French birth, although some of the most remarkable spent much of their lives in France, and all other Christian races seem represented. A feature absolutely common to the whole forty is great asceticism. Only four married, and all were in the habit of extreme fasting, "macerating" their bodies either with hair shirts or various irons under their clothes, and many of submitting to bloody flagellations. Again, all, without exception, were ghost-seers, or second-sighted; and all subject to trances, either with loss of consciousness only, or of motion and flexibility too, in which case they were often supposed dead; and the last in our list, after lying in state three days, and being barbarously mutilated by his worshippers, for relics, was unquestionably finally buried alive.* Many were levitated only in these unconscious states; others, as Joseph of Cupertino (the greatest æthrobat in all history), both in the trance and ordinary state, and (like Mr. Home) most frequently in the latter; while a very few, as Theresa, seem to have been always conscious when in the air. Several were, in certain states, fire-handlers, like Mr. Home. The Princess Margaret was so from the age of ten. Many had what was called the "gift of tongues," that is, were caused (doubtless in an obsessed state) to address audiences of whose language they were ignorant. Thus the Spaniard, Vincent Ferrer, is said to have learnt no language but his own, though he gathered great audiences in France, Germany, England, and Ireland. Connected with this, we should note how general a quality of these persons was eloquence. All the men (unless the two kings), and most of the women, were great preachers, though few wrote anything, except Bonaventure and Thomas in the thirteenth century, and Theresa in the sixteenth, who were the greatest Catholic writers of their ages. It is also very notable that the list contains the founders of six religious orders—the first special preaching order, Dominicans, the Jesuate Nuns, Minim Friars, Jesuits, Carmelite Nuns, and Oratorians; and all of these, except the second, great and durable .

The great majority of them, though often seen suspended, were at heights from the ground described only as "a palm" half a cubit, a cubit, and thence up to five or six cubits, or, in a few cases, ells. But the Princess Agnes and the Abbess Coleta were, like Elijah, carried out of sight, or into the clouds; and Peter of Alcantara and Joseph of Cupertino to the ceilings of lofty buildings. The times that these and others were watched off the ground often exceeded an hour; and the Archbishop of Valencia (1555) was suspended in a trance twelve hours, so that not only all the inmates of his palace, and clergy, but "innumerable" lay citizens, went to see the marvel. On recovery, with the missal he had been reading in his hand, he merely remarked he had lost the place.[*] In this and all cases the subjects were either praying at the time, or speaking or listening to a particular religious topic that, in each case, is recorded to have generally affected that person either with trance or levitation. We have seen that Apollonius vanished on declaiming his favourite verse of Homer. So the topic of the Incarnation would cause Peter of Alcantara to utter a frightful cry, and shoot through the air "ut sclopeto emissus videretur;" that of Mary's birth would have a like effect on Joseph of Cupertino; and Theresa, after obtaining by prayer the cessation of her early levitations, was yet obliged to avoid hearing John à Cruce on the Trinity, finding that this topic would cause both him and her to be raised with their chairs from the floor. A contemporary painting of them in this position, beside the grating where it occurred, has been engraved in the volume above cited. Joseph of Cupertino, on entering any church having a Madonna or his patron, St. Francis, as an altarpiece, would be borne straight thereto, crying, "My dear mother!" or "My father!" and remain with his arms and robe so among the candles as to alarm all with the danger of his catching fire; but always flying back to the spot whence he had risen. Others were raised up to images or pictures, as the Abbess Agnes in early girlhood, often before a crucifix, "in tantum eam arripuit amor Sponsi sui, quòd relictâ terrâ tam altè fuit corpus suum purissimum sublevatum in aëre, quòd ipsi imagini, supra altare in eminenti loco positæ, se pari situ conjunxit; ubi osculans et amplexans, visa est super Dilectum suum innixa."

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* This appalling story of insane superstition, to be paralleled probably among no non-Catholic people on earth, will be found in "Acta Sanctorum Octobris," Vol. XII., p. 158-60.

Of invisible transfers to a distance, the only subjects seem to have been Columba of Rieti, said to have been carried from her mother's house in that town to the nunnery that afterwards received her, at Spoleto, twenty miles distant; and the river transits of Peter of Alcantara. The lives of Joseph of Cupertino, indeed, allege that the rare miracle of "geminatio corporis," or bodily presence in two distant places the same day, was twice vouchsafed to him while dwelling at

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[*] This prelate, the annual income of whose see was 18,000 ducats, had no sooner settled in his palace than he got rid of all luxurious furniture, and made it a hospital or poor-house; himself often sleeping on straw, if beds ran short for the paupers. Charles V. had named another person for this see, but the secretary to whom he was dictating mistook the name, and, taking another paper, said, "I imagined your Majesty to have said Thomas of Villanova, but the error will soon be rectified." The emperor said, "By no means: the mistake was providential; let it stand."

Rome—once to assist at the death-bed of a named old man of his native village, whom he had promised to attend if possible; and again at the death of his mother. It is also related of the great Spanish æthrobat that, while the business of a jubilee detained him at Madrid (1556-9), a lady, Elvira de Caravajal, in Estremadura, declared her resolve to have no other confessor till Father Peter might be within reach; and the same day he presented himself in her castle, announcing that he had been brought expressly from Madrid, and that she ought not to choose confessors so distant. There is doubtless plenty of exaggeration, and many stories of this kind must be apocryphal, but the notable fact is that they are told only of the same persons as the fully-attested levitations and other phenomena parallel to the modern so-called spiritism.

The river transits of Peter of Alcantara have all the testimony we could expect for events of a past century, in that of the witnesses examined at his canonisation. Coming, during a flood, to a ferry on the Tagus, called Alconete, where it receives the tributary Almonte, he could not persuade the ferryman to risk the passage; as night came on, and he was due and urgently expected on the other side, he prayed for some means of transit; when he suddenly found himself at the door of another ferry-house on that bank for which he was bound. Under perfectly similar circumstances, he was similarly helped at a ferry on the Douro called Buycillo. Again having to cross the Tagus, from Portezuelo, where he left a companion exhausted, to reach a convent that expected him, at Garrovillas, he could by no cries arouse the sleeping boatman, whose house was beyond the river. While praying, he found himself before a house unknown to him, with the river beyond it; and, seeing lights, he besought the inmates to tell him if he could anywise be put across, as he was expected at Garrovillas. They asked what the reverend Father meant: was he not just come from thence? No, he had come from Portezuelo. They assured him he must be dreaming: that nobody could come thence without crossing the river. The miracle was at length perceived, and thanks rendered. After this, we find him arriving with a companion, at a place where the swollen Guadiana had to be crossed, and the ferryman would not venture. The above experiences had given him faith to do what? Pray for a repetition of them? No; such a prayer is at no time ascribed to him, but conduct both more humble and more scriptural. Ordering his companion to tuck up his robe, and follow his footsteps, he leads on, like his namesake of old upon the lake of Galilee, or the two prophets, or Joshua's priests long before; and in the sight of the ferryman, and many others on each bank, both walk across, wetted "hardly above the feet,"* though all knew the river to be, when lowest, never fordable at this place, and it was now in a high flood.

As bearing on the *dark séance* question, it may be remarked that each of these four passages was after sunset, though none, like that in the gospels, after midnight. Again, Christians who may be inclined to suppose their Master's works of any kind necessarily unequalled, must be reminded that if so, they make him to have prophesied falsely in John, xiv., 12.

A singular feature alleged of Mr. Home, and of levitated inanimate objects, occasionally has been their rapid gyratory movement. Precisely the same is recorded of an early mediæval case, the Flemish nun, Christina, who was liable, when conversing on the Lord, to be caught from her sisters and spun like a top;† and the same occurred in some of the trances into which similar conversations would throw Peter of Alcantara. Instead of rising to the level of the tops of trees, or being shot into the church as from a bow, he was sometimes hurried with a speed "as that of the wind" (though old and infirm), and without touching the ground, through various passages, to either his cell or the church, where he would then remain for hours insensible. Once, on hearing the words *In principio erat Verbum*, &c., chanted, he thus rolled away like a wheel, but raised a cubit from the ground.‡

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* The expression "dry shod" in the Old Testament, may very probably, even in the Hebrew, and still more so in the lost tongue whence Samuel translated it, have meant only with dry body garments.

† "Cum ipsis aliquando sedendo loqueretur de Christo, subito et inopinatè rapiebatur à spiritu, corpusque ejus velut trochum ludentum puerorum in vertiginem rotabatur, ita quod ex nimiâ vehementiâ vertiginis nulla in corpore ejus membrorum forma discerni posset."

‡ "Accensus spiritu genua et caput inflectens, implexusque tanquam rota volatu celerrimo ad portam conventus, indeque per alias portas sine ullâ læsione ferebatur, ultra cubitum à terrâ elevatus; usquedum coram SSS. Sacramento in ecclesiâ, in altissimâ, extasi raptus substitisset." It should be remarked that the grace of "maceration bestowed on this saint, and the physical toughness implied, were perhaps unequalled. His nightly sleep was less than two hours, with the forehead leaning against a wooden rest, his cell being, to prevent any posture but kneeling, planned two feet by four, and too low to admit of rising. For forty-six years he went in all weathers bareheaded and without sandals; and after washing his clothes, would wear them dripping wet. Before his daily flogging, he thought it necessary in winter to make the skin more sensitive by exposure to the frosty air. He ate usually but once in three days, and sometimes fasted for eight; and so admirable, said St. Theresa (who preserved these particulars), was the attenuation of his body and limbs, that they resembled a bundle of roots.

Another modern phenomenon often remarked is the rising of a group of bodies, animate or not, preserving their mutual contact and relations though loose. This was equally noted centuries ago, not only of Juan de la Cruz and Theresa with their chairs, but of all who were levitated in a kneeling posture, the loose robes adhering as if still pressed by the floor. It was especially so described in the case of Philip Neri, whose levitations, sometimes to three or four ells, were chiefly witnessed as he knelt at the rails of the great altar in St. Peter's (the present building, though then unfinished). Paintings constantly represent this phenomenon then with good reason.

Though in all the cases since 1500 the acts of canonisation record plenty of named witnesses who swore to these occurrences, none are so superabundantly attested as the innumerable flights of Joseph Desa, known, like most Italian ecclesiastics, only by the name of his native place, Copertino. Nor have the miracles of any other, that we know, effected anything so important as the Romanising of a Protestant sovereign. This friar was of very low birth, a tailor's son, and driven, apparently by harsh treatment from his mother, to seek the most menial positions in various convents from the age of seventeen. He was all his life liable to periods of extreme religious melancholy, and, when not in these, to trances and fits of various kinds. After monastic vows, he became a priest and preacher, and more and more gifted with miracles of healing, till, at the age of thirty-three, these brought him into trouble with the Inquisition, and he was cited first to Naples and thence to Rome, to clear himself from the imputation of starting some new heresy.* His orthodoxy, however, was established, and the general of his order introduced him to several cardinals, and to the Pope, Urban VIII., on approaching whom, to kiss his toe, Joseph's reverence to Christ, whose majesty he held the pontiff to represent, caused him not only to fall into a trance, but to be raised from the floor, and suspended, to the astonishment of all, until his superior ordered him otherwise. The Pope, highly astonished, observed that if Joseph died in his pontificate, he would himself be able to give testimony of this marvel. He was sent to the monastery of his order's founder, Francis of Assisi; and from thence the fame of similar wonders spread, till, in 1650, occurred their most important result. Prince John-Frederick of Brunswick, aged

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* "Accusationis hæc summa fuit; Discurrere per eas provincias hominem triginta trium annorum, et hunc alterum Messiam totos vicos post se trahere cum prodigiis ad singulos passus, celebratis à plebe, quæ omnia credit."

25, who was heir to either that Protestant state or Hanover, whichever might first fall vacant, and who afterward succeeded to both, was now on an European tour. Having heard of the wonderful monk of Assisi, his curiosity led him from Rome to visit that place. With two counts, a Catholic and a Lutheran, he arrived there on a Saturday, begging one interview with Friar Joseph, and intending to depart the same day. The superior, who had been warned of the arrival, and well instructed how to act, lodged them, and prevented any sight of Joseph till the next day, when they were introduced by a secret door into the chapel where he, uninformed that any stranger was present, had to perform mass. As had been expected, an impressive part of the service overcame the speaker, he became unconscious, and, as frequently happened in these trances, rose and floated some time in the air. Questioned afterwards by the superior, but still unaware that strangers were listening, he could only tell that he had fainted; that before the swoon he had been trying in vain to break the holy wafer; that afterwards he broke it, but with difficulty; and that this preternatural hardness, he had no doubt, indicated some hard-hearted heretic to have been present, for whose conquest let them all pray. The prince's curiosity, growing with what he had seen, kept him there another day. On Monday, Joseph, while elevating the host, again swooned, and was seen to rise following it, and remained suspended with his knees and feet one palm (or by another account a foot) from the floor; while the clear face of the wafer, visible throughout so small a chapel, became marked with a cross of jet-black —in short, as clear a case of what is now called "direct spirit-drawing" as Mr. Dale Owen has ever described. The friar, in an insensible state, yet holding up the monstrance over his head, hung immovable in the air an eighth part of an hour. The Lutheran count said, "It was a cursed day that I came into Italy. At home I always enjoyed a quiet mind; but in this country, puzzles about faith and conscience keep pursuing me." The prince sought more interviews with Joseph, and before a third day had elapsed, he had solemnly promised to believe "all that the Catholic Church believes," and as soon as he could satisfactorily dispose matters in his states to that end, to return and be formally received; which accordingly he fulfilled in about a year, at the same place, on his knees, before two cardinals and Friar Joseph.

After this the friar had to be removed successively to more and more secluded mountain convents, to avoid the excessive crowding of people to Assisi, and wherever he performed mass, which at length he was forbidden to do publicly. His aërial flights, and more frequent trances, to which he had been subject from the age of eight, continued, the former to his last year, and the latter to his last day, in 1663, at Osima. Four biographers soon published memoirs of him, one at least during the life and with the approbation of Prince John's widow,* a Bavarian princess whom he married in 1668, after becoming Duke of Hanover.

With the unfortunate Bonaventure of Potenza, buried alive by his devotees in 1711, seems to have ended the series of saints (and such they undoubtedly were) in whom this phenomenon of levity was inseparable from their devotions; and about the same time we disposed of our last witch—Protestantism, though finding no saints to canonise, having, through its first two centuries, thousands of witches to burn. And this must never be left out of account as bearing on the present rarity of these phenomena. They are rarer than in any century before the last, because hereditary psychics are rarer; necessarily after so persistent an attempt at their extermination. The mother of the Eddy family is said to be great-granddaughter of one of those condemned in girlhood at Salem, in Massachusetts, but who broke prison. We may conceive the artificial clearing of our race from psychics to be as possible as was the clearing the vertebrate kingdom of the dodo; and if—as might have happened by a few Biblical words being slightly better translated—our ancestors, two centuries back, had killed fewer of them by 30,000, would there not naturally be now several times 30,000 more of them in the world than at present?

It should be noted, respecting the Prince of Brunswick, that whatever power or intelligence superintended those miracles, that power showed great ignorance of the future. At the time, indeed, no conversion could seem more important to the interests of Catholicism than that of this young German sovereign, but eventually it appeared that any other ruler would have had more permanent influence. In fact, all public effect of his pious dispositions absolutely ended with his life in twenty-nine years. Though he lived till

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* "The biographers were Nutius, Agellus, Pastrovicchi, and Bernino. Late editions of the two latter are in the British Museum, and have frontispieces in each of which Joseph hovers in the air, in one before the top of a tall calvary; in the other borne forward fifty paces at sight of the church of Loretto. Pastrovicchi says, in page 87 of this edition:—"Attesta la Serenissima di Brunswik ancor viva mentre questo Libro scriviamo, qualmente in quella Corte a tempo del Duca Gio: Frederico suo Marito, *Non ci faceva oltro, che parlare del servo di Dio, Padre Fra Guiseppe da Copertino, al quale egli conservava una tenerissima divozione, e ne aveva l'Effigie,*" &c.

1679, and had four daughters, all his states of Brunswick, Hanover, Calemberg, and Grubenhagen, passed, for want of a son, to his Protestant brother, Ernest Augustus, father of George I. Plainly, then, if the power directing the Assisi miracles could have looked forward but a few years, not this heir-apparent, but his younger brother, also on his travels, and of similar education and disposition, would have been chosen. His conversion, though not then looking so important, would, in all present probability, have recovered to Rome by this time great part of Germany. What dynasty England might have chosen is of course impossible to guess; but his posterity would not, by being Catholics, have been excluded from any of the continental thrones they have actually filled.

The conclusion we draw is, that the very common notion of our having, or philosophers having, divided all describable events into the "naturally possible" and "naturally impossible," and assuming to have fixed this limit, can lead to nothing but priestcraft and superstition. Unless our calling things "impossible" could prevent their happening, it only gives them prestige whenever and wherever they may happen. Prince John of Brunswick was probably brought up to hold very nearly these most falsely-called "positivist" ideas—and we see the natural result. The more impossible or preternatural a Faraday or Comte can persuade us to consider any feat, the more helplessly will its occurrence hand us over to whatever body of men or other beings can at all manipulate that feat.

IV. THE BOUNDARY BETWEEN MAN AND THE LOWER ANIMALS.

TAKE any man of fair average understanding, whether educated or not; set him to arrange a crowd of things whatsoever, capable of classification; the probability is that, except specially trained in the study of the natural sciences, he will group them under two heads. These two classes he will take to be not alone mutually exclusive, but utterly antagonistic. He will assume them to be separated by a "hard and fast" landmark. We may tell him, if we think proper, that Nature—pardon the personification—does little *per saltum*. We may take his two classes, A and B, and show him how the one fades into the other, not by steps, but continuously and insensibly. We may point out that class B contains forms differing respectively from each other quite as much as some of them do from A. We may prove that facts would warrant a division into three, or ten, or twenty groups, as well as, or better than, into two. Or we may show that the classification is, in its principles, arbitrary, unnatural, and *ex parte hominis*, resting not on any difference in the matters to be arranged, but merely on the relation they bear to the convenience or prejudices of man, or of some particular section of men. All our explanations and objections will have little weight; man will have his two classes, and no more. This inbred tendency to dualistic arrangements, or to dichotomy, as it is called by some writers, is probably founded upon a bodily fact. Man has two hands. Place before a child a quantity of flowers, shells, or pebbles, and he will generally scrape them into two heaps, to the right and to the left. This mode of proceeding follows man from childhood to maturity, from savagery to civilisation, and from objects materially under his hands to those presented to his mind only. Had he been a three- or a four-handed animal, his philosophies and his creeds would have been greatly modified. Our binary or dualistic classifications, like our decimal arithmetic, have a morphological basis.

Instances of these binary divisions are plentiful, from the categories of Aristotles, or even from an earlier date, down to the present day. Every science, every branch of erudition, has its antithetical couples strung together, like braces of birds in a poulterer's shop. We speak of Ormuzd and Ahriman, of earth and heaven, of matter and spirit, of matter and force, of nature and man, of good and evil, of soul and body, of light and darkness, of heat and cold, of conductors and non-conductors, of metals and metalloids, of acids and bases, of combustibles and supporters of combustion, of organic and inorganic, of animals and vegetables, of man and beast.

The same love for dualism shows itself in the affairs of daily life, and in common conversation. Thus, the raw youth and—oddly enough—the statesman divide mankind into friends and enemies; our divines have their saints and sinners, their church and world, and other antitheses not a few; our moralists enlarge on vice and virtue; our political and social orators have much to say concerning order and progress, liberalism and conservatism, capital and labour. We speak of white men and men of colour, forgetting that

Celts, Teuton, and Slav are as remote from each other respectively as any of them are from the swarthy Aryan of India, and that the latter approaches no nearer to the negro than do our worshipful and self-worshipping selves. We are prone to contrast Englishmen with foreigners. We do not, indeed, conceive that the latter class is perfectly homogeneous: we admit that there is some little difference between a Frenchman or a German on the one hand and an Ashantee or a Papuan on the other; still we hold that all foreigners differ so widely and fundamentally from Englishmen that such nice shades of variation may well be overlooked.

Here also belongs that tendency to "successive halving" upon which the English opponents of the metric system of weights and measures—such as Sir J. Herschel—depend as one of their chief arguments. They tell us that it is "an instinct of human nature" to divide everything into two portions—that the hundredweight is thus halved and halved again down to the 3½ lb., and that the authorities have even been memorialised to sanction the use of a 1¾lb. weight. All this is a further illustration of man's natural proneness to dichotomy.

There is a singular feature in certain cases of binary arrangement, which may be most readily understood by a reference to the views prevailing in chemical science during the first quarter of the present century. Oxygen was, tacitly at least, singled out and placed in one class by itself, the remaining elementary bodies forming the second. It was the great element, as much superior to the rest as "man" is to "beast," as "Englishman" is to "foreigner"—we might almost say as "respectable Englishman" is to "pauper." Every newly-discovered substance was primarily, if not exclusively, studied with reference to oxygen. Wheresoever it entered it was supposed to play the active part, other substances present in the reaction being merely passive. Thus it was the "supporter"—the cause—of combustion, whilst the substances with which it united—compounds of carbon, hydrogen, and the like—were merely combustibles, bodies capable of suffering or undergoing the process.

This is a typical and an instructive case. In his binary arrangements man is very apt to take the one class in his right hand, if the phrase may be allowed, and to view it with especial interest and favour. Nay, sometimes this exceptional favour is the only base upon which such classifications rest.

We do not mean to lay down the law that every binary arrangement must needs be rejected. There may be cases where a division into two groups is quite natural and justifiable. Such groups may even be exclusive, and to some extent antithetical. Thus we may feel bound to refer all substantive entities to the two classes, "matter" and "spirit." We may neither be able to break down the boundary between these two groups, nor to point out a third co-existing group. Still, the possibility of matter and spirit being both phases of a something as yet hidden is gradually dawning upon some of us.

Looking, again, upon material objects, we may feel forced to regard them as either "organic" or "inorganic." The distinction between these two groups may grow less and less striking as our knowledge extends, but it does not entirely vanish. Still less does a third group make its appearance.

Again, the division of the higher forms of animal life into males and females—obnoxious as it is to the champions of the Woman's Rights Movement, and inconvenient as it proves to a certain class of world-betterers—can neither be abrogated nor explained away. There is, to be sure, a time in the life of hen pheasants, and other female gallinaceous birds, when they—in the magniloquent language of a weekly literary organ of epicœnes and garotters—"rise up and look their tyrant in the face," in the hope that, "ever after, he will sit uneasily on his" roost. In plainer words, hens who reach a "certain age" assume, to some extent, male plumage; attempt, not very successfully, to crow; and make themselves generally ridiculous, by attempting to be what they are not. Does such a change come over not merely individuals, but whole species, and is the human race approaching the time for this change? If so, there is an opening for some of "our poor relations." If differentiation means development, what conclusion must be drawn from the effacement of differences?

In spite, however, of the above-mentioned exceptions, and of a few others, real or apparent, I maintain that every case of binary classification is suspicious, as being probably *ex parte hominis*. The history of Science fully justifies this caution. The successive overthrow of such arrangements is certainly not the least striking feature in the career of modern discovery. This assertion I shall briefly endeavour to make good.

In the dark ages—or ages of faith, as they are called by men of the De Maistre school, who wish their revival—no antithesis was more common and more firmly established than that of "earth and heaven." The planets were not then known to be bodies composed of the same ultimate elements as our earth, governed by the same physical forces, and consisting, in the main, of a nucleus partly solid and partly liquid, surrounded by an atmosphere of gases and vapours. They were supposed to be semi-spiritual in their nature, formed of no one knew what, perfectly spherical in form, and free from such blemishes and imperfections as hills and valleys. The moon alone, being "lowest" and nearest to the earth, had in consequence—as generally happens to those who indulge in "questionable" company—contracted certain stains and impurities. Readers not conversant with the history of astronomy will find difficulty in believing that such was the interpretation put upon those spots in the moon which the telescope resolves into mountains, chasms, and ravines. As for our earth, it was regarded as a place utterly vile and "impure," the "sink of the universe,"—differing from the heavenly bodies in its nature, and contrasting with them in every respect. Those very features which conduce most to its beauty, and which alone render it habitable, were considered as proofs of its vast inferiority. These absurdities were recognised as philosophic truths; they were consecrated as articles of the true faith, and reigned for centuries unchallenged. Between earth and heaven there was a "great gulf." But the progress of astronomy showed finally that the earth and the remaining planets were sister orbs, between which no such antithetical distinction could be maintained. The "great gulf" was found to be merely the fog and darkness of ignorance, and, as it has been beautifully expressed, "earth was restored to her place in the heavens."

Turning from astronomy to chemistry, no antithesis in science was more firmly established a hundred years ago than that of acid and alkali, or, as we should now say, of acid and base. But in the progress of research it was found that one and the same body could fulfil either of these functions according to circumstances. Thus alumina in contact with a body more basic than itself—such as potassa or soda—plays the part of an acid; but if brought together with a substance of a more decidedly acid character—such as the sulphuric or nitric—it acts as a base. Thus the old absolute view of acid and alkali as two classes, mutually exclusive and essentially antithetical, has passed away, and the terms have acquired a mere relative significance. In this case the change of view was fortunately not retarded by any extraneous complications, such as social or theological prepossessions.

Very similar has been the case with the classification of the simple or elementary bodies. The science of the past had here, also, its dichotomous arrangement; metals and non-metallic bodies, or, as the French and Germans call them, metalloids. To apply the term metal*loid* to a body which is all the time proclaimed eminently *unlike* a metal is one of the curiosities of scientific nomenclature. To fence in these two classes with strict definitions, and to assign to every element its place in one or the other, were tasks on which learning and research were freely spent. And what is the result? That now there are several elements which form a debateable land between the two classes; that the love of paradox has caused one of the very bodies from which the idea of metal was originally obtained to be proclaimed non-metallic; and that the most truly philosophic chemists are beginning to regard the whole question as comparatively unimportant.

Turning to Physics, we may be reminded that "heat and cold" were once viewed as distinct and antithetical forces. The zero of our ordinary English thermometrical scale is a fossil remnant of this supposition. At 32 degrees below the freezing-point of water it was held that there was an absolute privation of heat, and that below this only greater or less degrees of cold could be experienced. Now every man of science, every person of decent education,—always excepting the author of "Trinology,"—conceives of cold merely as a degree of heat which is low in relation to his feelings, or to his general experience.

Let us look next at the antithesis "vegetable and animal," somewhile accepted without demur. We have still no difficulty in distinguishing the higher forms of "kingdom," as they are inaptly designated. We do not confound the eagle with the oak, or the donkey with the thistle. But on the confines there is here, again, a debateable land across which man has hitherto been unable—and finds himself from day to day less able—to erect one of those sharp, glaring, property-like fences in which his soul delights. An appeal was made to chemistry to find some absolute distinction between animals and plants. For a time the appeal seemed likely to be successful. We were told that animal matter contained nitrogen, which was wanting in vegetables. But soon nitrogenous bodies analogous to albumen and caseine were found in the seeds and in the juices of plants. It had been said that animal matter exposed to destructive distillation yielded ammonia, whilst by treating vegetable substances in a similar manner acetic acid was obtained; yet 99-100ths of the ammonia of commerce is derived from the destructive distillation of a vegetal matter,—namely, coal. Next certain substances were pronounced exclusively peculiar to the vegetable world—such as starch, alkaloids like quinine, and colours like indigo. One by one these, or their representatives, have been traced in the animal world. As a last resource the advocates of a chemical distinction selected protagon—a substance found in the nerves of animals. But alas! even this compound has been distinctly recognised in the grain of Indian corn. Again, it was asserted that plants were entirely dependent in temperature upon the surrounding medium, whilst animals, to a greater or less extent, possess a temperature of their own. This view is also abandoned. Several flowers are distinctly and measurably warmer than the surrounding atmosphere. Thus, according to Garreau, the flower of *Arum cordifolium* has been found to have the temperature of 121° F., whilst that of the air was merely 66° F. On the other hand, the milk of a freshly-gathered cocoa-nut is several degrees colder than the atmosphere.

There are, of course, certain anatomical features upon which those who worship their own ignorance—under the imposing title of "common sense"—may rely as furnishing a criterion. Bones and nerves cannot be distinguished in plants; but neither can they be traced in all forms of animal life. Thus the old antithetical distinction between plant and animal becomes less tenable, less striking, the more closely it is examined.

So we might proceed with a large majority of the contrasted couples, either of science or of common life. We should find, almost invariably, that where a dualistic arrangement has been adopted, that it is either radically false in principle, that the two classes are not mutually exclusive, or that the presumed antagonistic groups are merely the extreme members of one connected series. We should find more and more evidence that Nature repudiates our pigeon-boxes, and that her groups are referrible not to any outside boundary or definition, but to an internal type.

But whilst Science is successively repudiating these antithetical couples of the past, and regarding them as mere "alms for oblivion," one case of dualism remains almost untouched. We still speak of "man and beast" as did our forefathers in the eleventh century. Man deems himself, not the first and highest member of a series—or group of series—including all forms of animal life, but a creature removed from them far more widely than is the ape from the coral-worm. He differs from them, according to his own view, not in degree but in kind. Swainson excludes him altogether from the zoological circle, and views him as the "aberrant" form of the spiritual world, having with animals relations not of affinity, but merely of analogy. Every attempt to point out his true place in the scale of being is rejected as insulting, cynical, even blasphemous. Curiously enough those who intellectually and morally approach nearest the apes, and in some respects fall below them, are most exasperated at being approximated to "mere brutes." Even some of the advocates of what is conventionally—though illogically—known as "Darwinism" stop short in their train of reasoning when they have reached the anthropoid apes, and discover grounds for not pushing the enquiry further. Whether their grounds for thus advising us to "rest and be thankful" are scientific or sentimental we shall not now examine. Those, however, who value consistency will find that man is at any rate much nearer to the brutes than his self-love is willing to own, and that the points upon which he relies to establish a "great gulf" between himself and the rest of the animal world—if not baseless assumptions—are, at the best, sadly inadequate.

Does language constitute the boundary line? So says a large amount of vague popular opinion, represented by such phrases as "dumb animals." So say also enquirers not a few, among whom a prominent place belongs to Professor Max Müller. Of a different opinion is Quatrefages.* We will therefore examine what element of truth is in this view. In how far can man claim the exclusive privilege of the "spoken word," commonly deemed co-extensive with reason? Have animals no means—whether by sounds or gestures—of communicating their notions and their sentiments to other individuals of their own species, or of nearly allied groups? Have the varied sounds they utter no meaning beyond the expenditure of a certain amount of superfluous vital energy? Domestic animals may possibly have learned from man the bad habit of not keeping silence when they have nothing to say. But a little observation will convince us that the sounds made by birds and beasts are regularly repeated under certain recurring circumstances, and are evidently understood and acted upon by others of the same species. This may readily be noted in the case of domestic fowls, whose vocabulary is rather extensive, and may to some extent be understood. It may be objected that these sounds consist chiefly of danger-signals, calls to food, or calls relative to sexual and parental instincts, and that—few in number, vague and indefinite in character—they make but a very faint approach to the character of a language. This may be here the case; but we have positive evidence that brutes are capable of connected thought—of trains of reasoning: this is generally allowed to involve, of necessity, the use of language, or of symbols of some kind answering the same purpose. Man, at all events, cannot think or reflect on any subject without the internal use of words. Coleridge, indeed, was of opinion that if language had never arisen, man might have come upon some method of conducting the reasoning process without its aid. But this view meets with little acceptance. This intimate connection of speech and reason is acknowledged in the idioms of several languages; but that language depends solely upon sound, and must be addressed to the ear alone, is a false assumption. The senses of sight and touch may each be the medium through which symbols of determinate meaning can be laid before the mind of an intelligent being. The language of ants, conveyed by varied touches with the antennæ, has been observed by many naturalists,—we need only refer to Mr. Belt,—and is clearly adequate to the communication and transmission not of mere danger-signals and calls to food, but of precise and definite information concerning duties to be performed. A messenger ant can send a number of his companions to some precise spot, and can inform them beforehand what task they are to undertake, just as well as a human messenger in a manufactory or an aide-de-camp on a battle-field. Nor is the ant who has brought intelligence obliged to go first to the place where help is wanted; those whom he has first touched rush off in the proper direction, whilst he goes on collecting more forces. The case, then, stands thus:—Man is no longer able to deny that brutes think. If he will not admit that they think in words, or by means of equivalent symbols, he is, I submit, bound to show that they think in some different manner, or by the aid of some other instrument.

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* Unity of the Human Species. The unity, by the way, of the "human," or of any "species," will doubtless be conceded, subject always to the question—What is included in such species?

There are on record authenticated instances proving that animals are capable of conveying or transmitting to each other, not mere general and vague intimations of good or evil, but pieces of distinct and specific information. Turning to beings which—morphologically at least—approach man much more nearly than the ants to which I have been referring, we find the following:—"A little Blenheim spaniel of hers once accompanied her to the house of a relative, where it was taken to the kitchen to be fed, on which occasion two large favourite cats flew at it several times, and scratched it severely. The spaniel was in the habit of following its mistress in her walks in the garden, and by degrees it formed a friendship with a young cat of the gardener's, which it tempted into the house,—first into the hall, and then into the kitchen,—where, on finding one of the large cats, the spaniel and its ally fell on it together, and beat it well. They then waited for the other, which they served in the same manner, and finally drove them both from the kitchen. The two friends continued afterwards to eat off the same plate as long as the spaniel remained with its mistress in the house."* How, without some kind of language capable of entering into special details did the spaniel persuade its friend to enter the house, and join in hostilities against two beings of its own species? Yet there are on record cases, not a few, of dogs and of cats which have brought allies from a distance to aid them in revenging an injury. To give all the well-authenticated and current instances where one animal has thus been known to convey to another some definite piece of information would be foreign to my plan, but there are many works on Natural History that will fully supply the deficiency.

I have next to call attention to the fact that domestic animals frequently understand what is said by man. I do not refer to words of command to which they have been trained, nor to other cases where the tone of the voice and the accompanying looks and gestures might reasonably be expected to throw some light upon the meaning of the speaker. Take the following instance:—A woman was often annoyed by the depredations which the poultry, and especially a certain young cock, committed in the garden. One day, after driving out the poultry, she said, in the heat of the moment, 'I wish that cock were dead!' A little favourite dog, which had been present as she spoke, ran out, and shortly afterwards returned, dragging in, to her surprise and horror, the lifeless body of the offending cock." We may grant that the dog had seen its mistress drive out the poultry, and knew thus that they were the object of her anger; but how, except from understanding her words, could he learn that the cock was, in her opinion, the main offender, and that she desired his death? Take another case:—"The Rev. James Simpson, of Liberton, had a very intelligent dog. He remarked one day to a friend, in its hearing, that he should be compelled to get rid of it, being about to change his residence. The dog forthwith disappeared, and never returned."*

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* Jenyn's Observations on Natural History, p. 71.

Further, instances in abundance could be brought to show that a dog very readily discovers whether his master is on a hostile footing towards any persons he meets, even where no threatening gestures or loud speaking may have occurred. If you talk about a cat in her hearing she will generally put on an air of affected unconcern, or rather unconsciousness, similar to that she assumes if a scrap is thrown to her when not very hungry. Now it is inconceivable that a being totally devoid of a language, and therefore unaccustomed and unqualified to receive communications through any such channel, could understand the language of man.

But if domestic animals have languages of their own, and do, to some extent, understand that of man, how is it that he is so little able to understand theirs? Perhaps his motives are much less urgent. Place two beings, A and B, in close daily contact, and give A unchallenged and unlimited power over B. It will then always be found that B will have a far clearer insight into A's principles, passions, prejudices, foibles, and character in all respects, than A, in turn, has into those of B. In the old times of negro slavery—say in Jamaica or Carolina—how little did "massa" really know of Quashie and Sambo, and how very much, on the other hand, they knew of him! Paradoxical as it may seem I feel compelled to assert that, within a certain sphere, the lower mind sees into—not comprehends, that is another matter—the higher mind better than the higher can see into the lower. The planet sees the sun, whilst the sun is all unconscious of the planet. Place yourself on the summit of a hill, and a spectator down amidst the fields or houses of the plain may watch your every movement, and yet escape your notice, despite—or perhaps rather because of—the wide extent of view you enjoy. Of course only minds similar in nature and equal in power can fully appreciate each other. The fool is unable to comprehend the aims and the motives of the genius, but he sees into the character of the latter, detects any apparent shortcomings, and draws his private advantage therefrom. "The children of this world"—*i.e.*, the commonplace, routine characters—"are wiser in their generation than the children of light."

Hence—if a brief digression be allowable—the little soul has, in dealing with his fellow men, a decided advantage, as shown in the following incident, which is no fable or apologue, but the literal record of a fact:—A certain man in the North of England had two sons, not palpably idiots, but what are locally known as "softies." One of these was suddenly missing. He was traced to a wood near the town, but there the clue was lost, and all search proved vain. In the afternoon the other "softy" begged that he might go in quest of his lost brother. The proposal was accepted, and the boy—followed at some little distance by his father—entered the wood. He sauntered carelessly up and down, with his eyes fixed on the ground, constantly shouting—"Aw see thee, Johnnie!" Suddenly a voice from the midst of a dense thicket replied—"Nay, thou duzzant." What wise man could thus understand the workings of a fool's mind? The real "*Encomium Moriæ*" has yet to be written. These considerations will go far to explain the frequent failure of men of genius to secure the ordinary material prizes of life,—a failure by no means invariably due, as sometimes asserted, to extravagance, indolence, or intemperance. This opinion will certainly be voted flat blasphemy against that god of the modern world, the "self-made man." His worshippers, literary or illiterate, may not relish the imputation that the peculiar and profitable gift of their idol for over-reaching inventors, customers, workmen, and all sorts and conditions of people, is nothing divine, but merely a slavish—and even a currish—faculty.

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* SHIRLEY HIBBERD, Clever Dogs, &c.

To return:—What wonder that man fails to understand the lower animals, just as the master is unable to understand the slave, or the sane man an idiot?

It may, perhaps, be argued that domestic animals have been so profoundly modified by contact with man, that they may thus have to some extent acquired the gift of language. I reply that, making full allowance for such modification, these animals must either have possessed the rudiments of a faculty for language or not. If they had when in a state of nature even the slightest germ of such a faculty, then absence of language cannot serve to distinguish the lower animals from man. If they had no such germ, and if the faculty for language could be created by mere association with mankind, then assuredly it is a characteristic far too unimportant to serve as the basis of a classification.

It is not, however, among domestic animals that the faculty of language appears most fully developed. Save among mankind, it appears in the greatest perfection among the social birds and insects—species which unite not merely in families, but in tribes and communities. To the ants I have already referred. Among rooks, some slight, but unmistakable traces of law, and of formal procedure against criminals, have been observed. This surely is inconceivable in the absence of language. In Guayana a great number of monkeys have been observed assembling upon a huge tree. A large old male, perched near the summit, delivered a long chatter, after which the whole assembly burst into a tumultuous jabbering and screeching. When this ceased, the orator resumed his harangue, and was again after a time interrupted by the whole chorus. Ludicrous as this sounds to us, can we consider it as utterly unmeaning? On the other hand, can we conceive of any meaning except the assemblage had some faint outline of a language?

In many instances it would be impossible for animals to alter their habits in conformity with changed circumstances, unless they were able to communicate information to their contemporaries and to their posterity. There are many circumstances proving that the lower animals possess the power of tradition. Look, for instance, at the dread of man shown by birds and mammalia in peopled regions. This fear is not innate, as we learn from voyagers who have visited uninhabited islands,* such as the Gallapagos or the Falklands. In such lonely parts the feathered tribes fear a man no more than they do a goat or a sheep. But wherever he sets his foot, his habits of promiscuous and wanton destruction become known with wonderful speed, and he is soon regarded as dangerous, and shunned accordingly, long before every individual bird can have personally observed the effects of a fowling-piece. Here, then, is a new fact, observed, remembered, and circulated. But the vague dread with which birds regard man when first his real nature becomes known is not permanent. They observe him, and note how far and under what circumstances he is dangerous, and also when and where he is powerless. This knowledge, also, is communicated. A town sparrow knows exactly how near it is safe to let a boy approach before taking flight. Its conduct, which may be regarded as cautious impudence, is a due medium between the unsuspecting confidence of the birds of some untrodden isle and the panic terror of those in rural districts. These and similar facts, which the field naturalist and the sportsman will call to mind in quantity, prove that the lower animals can tell each other what they observe and remember.

Some objectors may urge that the languages of brutes, be they vocal or signal, are not "articulate," and consequently bear no resemblance to those of man. So long as they answer a corresponding end, I consider this distinction immaterial. But every language seems inarticulate to those to whom it is quite unintelligible. The English peasant hearing a conversation between two Frenchmen proclaims it mere chatter, such as a monkey might utter, and in which he can recognise nothing like words. The ancient Greek called all barbarians "tongueless." The modern Pole, Wend, or other Slavic man, terms his German neighbours "mute." If, then, men fail to recognise the articulate character of human languages which they do not understand, can we wonder if sounds, produced by vocal organs differing more or less from their own, seem to them mere aimless growling, shrieking, and chattering? I am far from supposing that the languages of brutes are remarkable for regularity, complication, and richness of expression. But how wide is the diversity in this respect among the human race! The Veddahs of Ceylon "communicate with each other by signs, grimaces, and guttural sounds which bear little or no relation to distinct words."* If we assume that the languages of the chimpanzee and the pongo are as much inferior to the tongue of the Veddahs as that is, in turn, to Greek or Sanskrit, need we wonder, if to human ears the ape-dialects seem utterly inarticulate?

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* Darwin, Naturalist's Voyage, p. 398.

Finally, there are animals really dumb—devoid of vocal organs, and therefore incapable of mutual communication by sound; devoid also of antennæ or corresponding parts requisite for a language of signs; solitary, and therefore needing no language. The gulf between such animals on the one side, and the vertebrata and articulata on the other, is incomparably wider than that existing between the latter and man. Man has a very complicated and highly-developed speech; the ape, the rook, and the ant, a comparatively rudimentary, but the oyster none. If, then, the animal world is to be divided according to the presence or absence of this faculty, the line will fall, not between man and the anthropoid apes, but between the vertebrates and articulates on the one hand, and the molluscs and still lower forms on the other. Hence all attempts to establish a "great gulf" between "man and beast" by means of language are altogether illusive.

* Sir E. TENNANT, vol. ii.

V. SCIENCE, HER CLAIMS, POSITION, AND DUTIES.*

PROBABLY no literary production of the day has occasioned so much excitement as the world-famed Address of Dr. Tyndall. Although bringing forward no new facts, no novel generalisations, it has—in virtue of the occasion, and of the high standing and official position of its author—called forth a deluge of criticism, as unique in quantity as (we would fain hope at least) in quality. In clubs and in taverns, in public conveyances and at tea-tables, in pulpits and on platforms, Dr. Tyndall has been the denounced of all denouncers. From Cardinal Cullen to Dr. Cumming, from Professor Blackie to Dean Cowie, clericals of all creeds, "friars white, black, and grey," are leagued against the bold speaker. Dr. Magee has treated the world to a "Tale told by a bishop, full of sound and fury." M. l'Abbé Moigno has scarcely room left in his redoubtable "*tete bretonne*" for the great pyramid, and, not to speak of stray controversial paragraphs, has reprinted the speech with Ultramontane annotations, and addressed to Dr. Tyndall a serious and impertinent letter of remonstrance. As for the lighter attacks,—the cavils penned by fast *litterateurs*, or uttered by the self-styled "respectable and intelligent classes,"—they are absolutely beyond enumeration. Nothing more is wanting in this candid and appreciative style of criticism save that the "Address" should be solemnly burned at Oxford, and formally condemned by his Holiness the Pope. If, as it has been suggested, one at least of Dr. Tyndall's motives was to learn, by actual experience, how such a speech would be received, his curiosity has been fully gratified. There can be no doubt that, had the power been equal to the wish, he would, before this date, have shared the fate of Protagoras and Anaxagoras and Hypatia, of Roger Bacon and Virgilius of Salzburg, of Giordano Bruno and Vanini, of Telesio and Campanella, and many more who by some strange accident are *not* mentioned in Sir D. Brewster's "Martyrs of Science."

If, as we hold, there is much in the "Address" on which issue may fairly be joined, much that is incapable of demonstration, and more, perhaps, that is inopportune, not the less do we feel bound to protest against the bulk of its critics.

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* Address Delivered before the British Association assembled at Belfast, with Additions, by JOHN TYNDALL, F.R.S., President. London: Longmans, Green, and Co.

Their spirit and their point of view are equally faulty. To accuse a man of "having permitted the cheers of his audience to stimulate him to the utterance of words which no right-minded man could employ," when all the time he was delivering a speech previously drawn up and actually printed; to say, with Dean Cowie, that the Professor ended his speech "by terming himself a material atheist;" to speak of Professors Tyndall and Huxley as "ignoring the existence of God, and advocating pure and simple materialism;" or to represent our author as "patting religion on the back,"—is a style of criticism not recognised among gentlemen, and requiring more malice than subtlety, profundity, or learning.

Professor Tyndall, in some parts of his speech, had apparently forgotten that it is the duty of the British Association to confine itself to facts, and to inductions carefully drawn and rigidly verified, or at least capable of verification,—that Science deals not with noumena but with phenomena, and that the ground on which Lucretius and Bishop Butler wage their endless and fruitless warfare lies beyond her jurisdiction. Consciousness and sensibility are for us ultimate facts, about which we may speculate,—and quarrel, if foolish enough,—but which we can never explain. Instead, however, of pointing out where the orator had ceased to be scientific, they, with sublime inconsistency, denounced Science with an eagerness as if the matter had been prepared long beforehand, and merely an occasion had been sought for its delivery. The ostensible *casus belli* was the Belfast speech; the real quarrel seems to be with the scientific spirit in its legitimate manifestations, and with its growing influence in the world. Of this Dr. Magee's late sermon on the "Gospel of Science" is a striking example. There are minds who seek in everything what—for want of a better name—we term unvarying law, and to whom the arbitrary is essentially painful. There are other minds who have a no less decided craving for will and for personality. To this latter class some of Dr. Tyndall's critics seem to belong by virtue of race.* But has this class any right to forbid the former from even stating its views?

To follow the "Address" from proposition to proposition, weighing each along with the objections raised against it and with the fervid eulogies of Dr. Guardia,* would be simply a life-task. This will readily be granted when we remind ourselves that, in addition to the vexed question of "materialism,"—more correctly called *apneumatism,*—the transformation of species is one of the points upon which judgment must be given. Indeed, passing over the merely historical portion and the "drawn game" between Lucretius and Bishop Butler, the main part of the "Address" is devoted to an exposition of the speculations of Darwin, Huxley, and Wallace, on the origin of species, and to the researches of Herbert Spencer on the development of intelligence. To this part of the subject we are led by the remark that Bishop Butler "boldly embraced the whole animal world in his scheme of immortality," like the Rev. J. G. Wood in our day,—thus overthrowing one of the most formidable barriers erected between man and the lower animals,—and by a reference to modern geology and palæontology. We do not know whether due weight has been laid upon the circumstance that the infant chimpanzee and the human infant have a very considerable resemblance to each other, which, as the two beings respectively approach maturity, becomes smaller and smaller. What does this signify? If, standing on an eminence overlooking a wide tract of country, we see two streams gradually and continuously diverging from each other as they flow,—say, eastwards,—we very naturally conclude that if we could follow them in the opposite direction we should find them gradually converge. In the same manner the increasing divergence of animals, as they approach perfection, seems strongly to support the view of an ultimately common origin of species now apparently distinct. It is a ludicrous error to suppose that the doctrine of evolution is necessarily connected with the atheistic hypothesis of existence. Just the same charges were in former days brought against the heliocentric theory of the solar system. Should "transformism"—as the Abbé Moigno inelegantly calls it—become better understood, divines will cease to dread it, and we shall see once more the Church and the World yoke themselves side by side to the chariot of success. The recognition of the development theory is, however, retarded by an abuse to which one of its doctrines is put by a certain social school, and which gives a certain plausibility to such attacks as those of the eloquent and subtle, though sorely mistaken, Bishop of Peterborough.

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* It is a curious fact, not hitherto recognised, that all or nearly all Professor Tyndall's denouncers appear to belong to the Celtic race, as far at least as we may judge from their names. The Abbé Moigno declares himself a Breton, consequently a Celt of the Celts. Such names as Cullen, Magee, Fraser, Cowie, and Blackie speak for themselves. We believe that this rule will be found to hold good in other cases where men of science or scientific researches are attacked from the same point of view.

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* Moniteur Scientifique, November, 1874.

When Darwin, Wallace, Bates, Belt, and other practical naturalists, speak of the "struggle for existence" and of the "survival of the fittest," they mean by the term "fittest" simply that which is in the closest harmony with surrounding conditions. But outsiders—such as divines, lawyers, politicians, economists, and literary men—very generally go away with the impression that by this word the advocates of development imply whatsoever is in the abstract best and worthiest, or whatsoever is most useful to man and most beautiful in his eyes. Under the influence of this mistake they are led astray, in one of two opposite directions, according to their prepossessions. Those, on the one hand, who know that without man's active intervention worthless weeds would soon choke the precious grain, believe that they have here found the *reductio ad absurdum* of "Darwinism." On the other hand, certain economists who hold that success is the sole test of merit, and who believe the inventor who starves in a garret less "worthy" than the "financier" who robs him of his invention, fancy they see in the theory of development the scientific consecration of their private creed. Their consequent adoption of a part of its language brings "Darwinism" into contempt.

Scientific men should, above all things, insist that every scientific theory must stand or fall on its own merits, and not in virtue of its assumed "tendencies." We can acknowledge no extraneous jurisdiction. Time was when the Church claimed to be the depository not merely of spiritual but of physical truth; this usurpation is at an end. Science, no longer a "handmaid," sits crowned and armed in her own sphere. But here, as elsewhere, rights imply duties. Firmly and consistently as she must claim and hold the undivided right to the interpretation of the physical universe, no less firmly must she abstain from every attempt to extend her jurisdiction over the emotional phase of man's being.

Professor Tyndall, desirous, doubtless, to lay before the public some of the most recent and advanced results of modern speculation, was not happy in certain parts of his speech. If he did not actually cross the border, he appeared so to do. A teacher, further, should beware of needlessly exciting against himself and his views the passions of his pupils. It is rarely prudent to attack a prejudice in pitched battle. All that there is in this "Address" really valuable, truthful, and to the point, might, we believe, have been said without wounding the feelings of many estimable men, and without raising a storm, all whose results will scarcely be favourable to the cause of Science. One of the best remarks on the "Address" was made by the Abbé Moigno, on learning that it had been drawn up among the Alps. A speech dealing with such important subjects, and so liable to be misunderstood, if not wilfully misinterpreted, should, the Abbé declares, have been composed not amidst the incidents and distractions of travel, but at home, in the quiet of a well-stocked library. Can Professor Tyndall suppose that this speech and its echoes will make the present Administration and its supporters at all more disposed to give national education a scientific basis, or to liberate the Universities from ecclesiastical control? We fear that, though not foolish himself, he will be the cause that folly is in others. Little as he may be hurt by the attacks of his censurers, we imagine that he cannot help feeling compunction for having brought down upon the public the "weak, washy, never-ending flood" of speeches, sermons, resolutions, and leading articles, from which we have suffered for the last two months.

VI. THE SPECTROSCOPE IN ITS APPLICATION TO MINT ASSAYING.

By Alexander E. Outerbridge, Jun.

THE invention of the simple instrument called the spectroscope has led, within a brief period of years, to such astounding revelations, that it is not unnatural to imagine that untold possibilities may still lie concealed in its future. Those who are at all familiar with the subject of spectrum analysis, do not require to be told that the spectroscope has increased tenfold the range of human knowledge within the domain to which it is applicable; and has also reduced much of what has heretofore been little better than matter of speculation, to a certainty as convincing, to a scientific mind, as a mathematical demonstration. Applicable alike to the analysis of tangible substances and of the celestial fires, its mysteries have been wrested from it, as it were, from an invisible world, by its devoted students.

All the classes of observations hitherto accomplished, fall under the head of *qualitative* analysis, in which perfection appears to have been already attained. Should a like perfection be attainable *quantitatively*, little more would appear desirable. With the view of probing for new facts in this direction, a limited but promising field of experiment has lately been adopted simultaneously, but independently, in the assay departments of the Royal Mint in England, and of the U. S. Mint at Philadelphia, and the attempt has been made to insert the wedge of future investigation by obtaining from the spectroscope a quantitative analysis of the composition of metallic alloys.

In a late annual report of the Royal Mint, Mr. Wm. Chandler Roberts, the chemist of the Mint (who with Mr. J. Norman Lockyer, the pioneer in spectroscopic research, has been conducting a series of experiments), states he is satisfied that by means of the spectroscope very minute differences in composition of gold-copper alloys can be astained. He, however, "refrains from describing the process, as the exact method of manipulation had not been determined upon. In the following paper, which also appears in No. xcviii. of the "Journal of the Franklin Institute," the attempt is made to narrate, not technically, the process adopted, and the conclusion arrived at, in the experiments made in Philadelphia, the details of which are contained in a report by the writer to the chief assayer of the Mint, dated May, 1874, and published in the "Proceedings of the American Philosophical Society" of the 15th of that month, vol. xiv., page 162.

The beautiful parti-coloured band of light, resembling a section of a miniature rainbow, resulting from the passage of a ray of white light through a prism, is familiar to every one; this simple experiment forms an appropriate introduction to the fascinating study of spectrum analysis.

Every kind of light not strictly mono-chromatic may, by means of the prism, be resolved into its component colours. The spectroscope is a simple combination of prisms and lenses for the scientific examination of these different colours or spectra.

The numerous terrestrial elements, when in the state of incandescent vapour, give their own distinctive colours, which appear in the spectroscope as *lines of light* arranged in definite positions, whereby each element may be easily recognised.

The passage of powerful electric sparks (from an induction coil) between two terminal points of the metal to be ex-examined, vaporises a small portion of the metal, and this incandescent vapour transmits to the eye of the spectroscopic observer its *luminous-autograph* which nature never counterfeits. Should either or both of the metallic points, or *elec-*

trodes, consist of an alloy of two or more metals, the autograph of each may be clearly read.

Mr. Lockyer noticed, while studying these luminous autographs, that when he separated the metallic electrodes, causing the spark to leap a greater distance through the air, the spectral lines no longer continued to cross the entire field of vision, but certain of them *broke in the middle*, and upon further increasing the distance between the electrodes, the hiatuses in the spectral lines increased proportionately, *but unequally with different alloys.* As the proportion of either metal of an alloy is increased, *its lines lengthen*, and conversely with the lines of the other metal. Upon this discovery, Mr. Lockyer based the theory of a possible method of quantitative analysis.

The spectroscope was known to be marvellously sensitive to the impression of these autographs, and it therefore appeared plain that could such a method of analysis be reduced to a practical basis, its value would be immense in assaying metals used in coinage. For although the present modes of assaying precious metals have been brought to great perfection, yet the process is slow and tedious, requiring many chemical operations and great delicacy of manipulation; and "there is something captivating in the idea of a determination, as it were, by a flash of lightning, or in the twinkling of an eye, what proportion of gold or silver is present in any bar or coin."

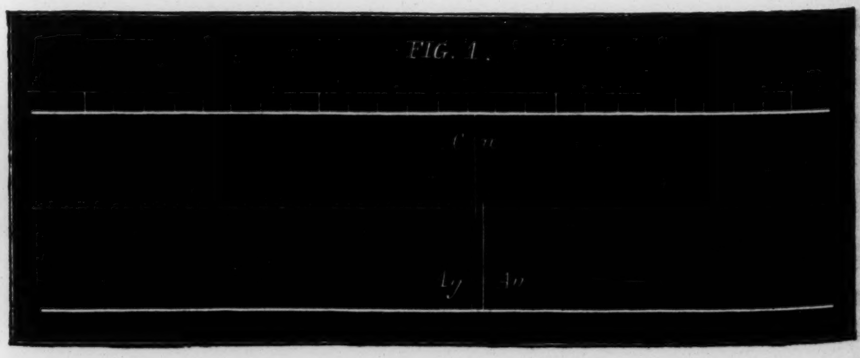
It was with the hope of reducing this beautiful theory of Mr. Lockyer to practice that these experiments were undertaken. The investigation extended over a period of several months, the principal part of the work being conducted at the University of Pennsylvania, with the benefit of the excellent apparatus and appliances afforded in the new college building—a privilege kindly extended by Prof. Barker of that institution.

A powerful induction coil, reinforced by Leyden jars, in connection with a two-prism Browning spectroscope, was employed, and it was found possible, after repeated comparisons of the spectra of different known alloys of gold and copper, to map the difference of fineness between specimens having respectively 500 and 750 parts of gold in 1000 of the alloy, and even to recognise the variation between coin-ingots 895 and 902 fine. This variation, within 7000ths, was by no means marked, although it seemed probable that a more delicate adjustment of apparatus, and further experience, would render the distinction more decided.

The spark, in passing through the air, also vaporises its constituents, viz., oxygen, nitrogen, &c.; these, of course, write *their* signatures in the spectroscope, and it is necessary to eliminate the numerous bright air lines which thus appear in all the spectra. Some of the lines of different metals appear in close proximity, and might readily be misinterpreted. Thus a bright blue line of bismuth is almost identical in position with one of zinc. A green line of iron is nearly coincident with a bright gold line. The difficulty which presented itself in the exact comparison of these proximate lines was overcome by using a pure metal as one electrode and another pure metal as the other electrode. The effect thereby produced was very curious. With pure gold and pure copper as the electrodes, the gold lines extend across only one half the field of the spectrum, and the copper lines extend only across the other half, the medial termini of both sets of lines being perfectly sharp and bright. By this means a double spectrum of copper and gold is obtained, or, rather, a section of a complete gold spectrum and a section of a complete copper spectrum are visible in immediate juxtaposition, thereby enabling a most accurate comparison of lines, which in reality are not identical in position, but which by the previous method were apparently so.

By a slight modification of the experiment, substituting pure copper as one electrode and an alloy of silver and gold as the other, the proximate lines of these three metals are presented mapped, as it were, on a natural scale. (Fig. 1.)

FIG. 1.



Further modifications of this principle suggested themselves, and were tried with indications of valuable results.

By using as one electrode an alloy of gold and copper of comparative fineness, and a baser alloy of the same metals as the other electrode, a result not before observed presented itself. The lines of both copper and gold crossed the entire field of vision, but in the section representing the fine alloy, the gold lines were strong and bright, while in the section representing the base alloy the gold lines were very faint. (Fig. 2.)

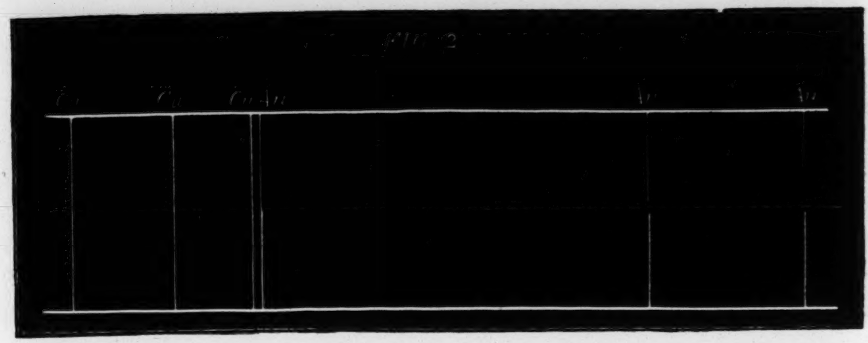


FIG. 2.

By now gradually increasing the distance between the electrodes, the faint gold lines of the base alloy cease to join their bright counterparts of the fine metal at the central line. (Fig. 3.)

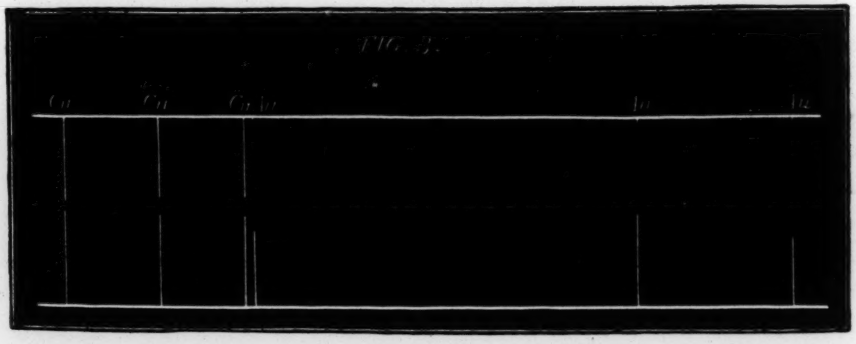


FIG. 3.

The intervening space is at first minute, but as the electrodes are further separated, the ends of the faint lines gradually recede towards the outer edge of the spectrum, until they finally disappear altogether.

The general principle was thus satisfactorily proved, that where two alloys of different grades are subjected to this treatment, the gold lines of the baser compound are noticeably the fainter of the two, and, what is more important, they may be reduced in length by separating the poles, until they disappear.

This pointed to the possibility of the future application of spectrum analysis to assaying, at least, as a test method. For, if an alloy of absolute known fineness were adopted as one electrode, and an ingot-slip assayed by the old process to an equal grade of fineness were inserted as the opposite electrode, in case the assay were correct, the gold lines in both sections of the spectrum should appear of equal brightness, and, more especially, should begin to recede from the central line of the spectrum at the same moment, and should disappear at the same moment.

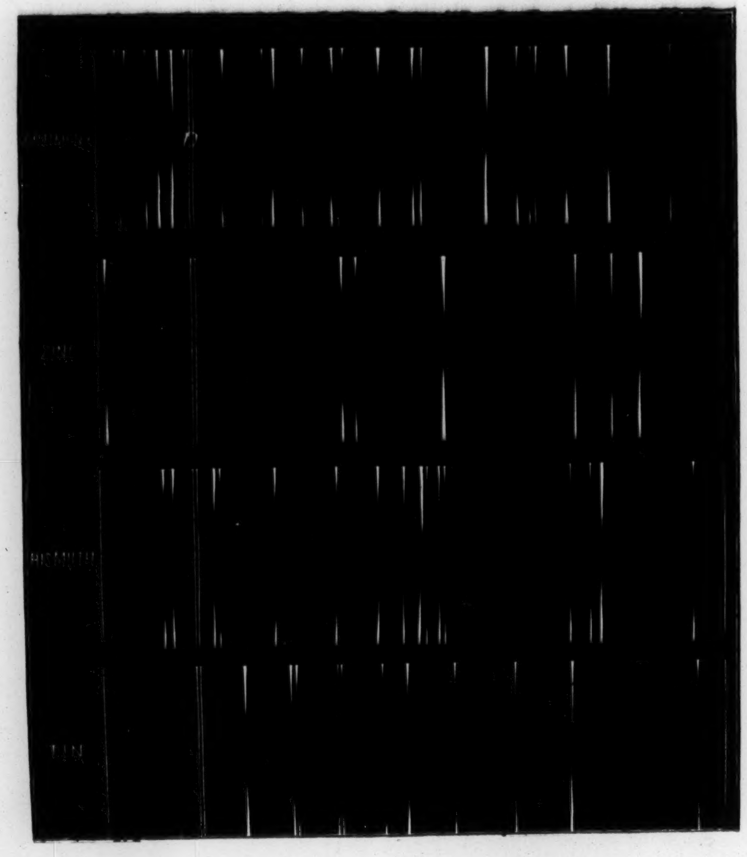
The spectra being inevitable natural effects of physical causes, a variation between two specimens of supposed equal fineness would, *in theory*, be necessarily indicated by the respective lines failing to correspond in their reciprocal action.

A serious source of error in these comparisons was soon discovered, viz., that if one electrode was nearer the centre of the slit of the spectroscope than the other, its spectral lines would appear proportionately longer than those of its *vis-a-vis*, even though both electrodes were of the same pure metal. It then became necessary to devise a special apparatus for manipulating the electrodes when under examination. This was constructed by Mr. Samuel James, the machinist in the Mint, and admirably fulfilled its object. A woodcut of it is appended hereto. Its peculiarity consisted in an automatic combination of accurately proportioned screws, acting in opposite directions, by which a single motion of the hand sufficed to cause the upper and lower electrodes to approach or recede from the central line of contact in an equal degree. The electrodes, which consisted of small strips of metal cut to a point, were held by a suitable arrangement on the outer circumference of two metallic rings insulated from each other, the upper one slotted to receive a series of twelve electrodes of varying *known* fineness, and revolving horizontally, so that each electrode might in turn be adjusted to face a single electrode of *unknown* fineness fixed on the lower ring. Its object was to admit of the electrodes being separated to any desired extent, while preserving the line of vision through the spectroscope, directed to the centre of the spark.

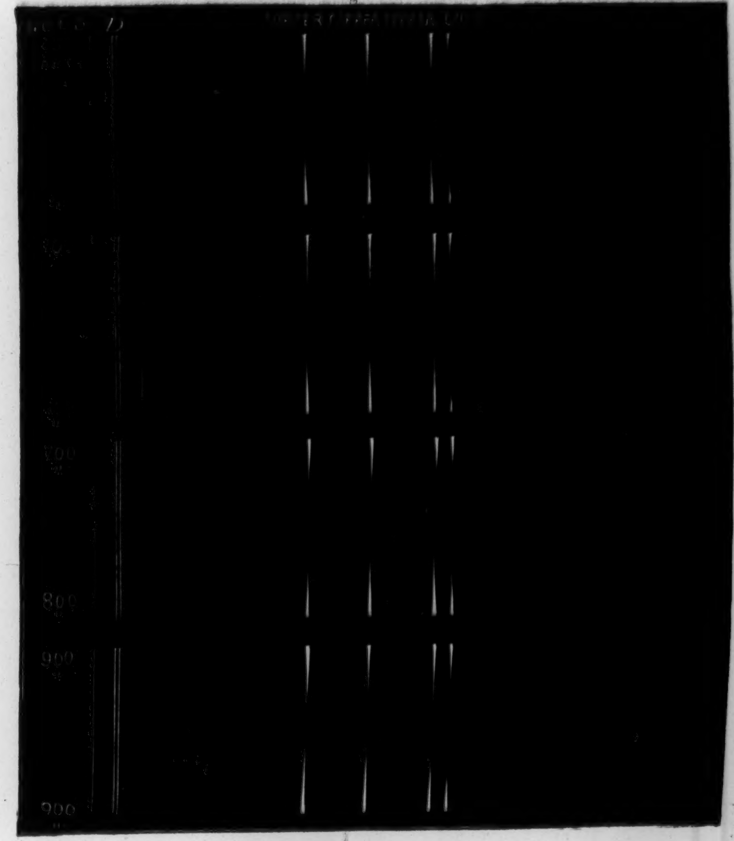
In regulating the height of the instrument, the apparatus was always adjusted by passing the spark between two electrodes of pure gold, so that, on separating the points, the respective spectral lines corresponded exactly in their reciprocal action.

A systematic series of experiments was now commenced, in which the behaviour of the more volatile metals was at first studied, viz., lead, zinc, bismuth, tin, antimony, cadmium, mercury, aluminum, &c. All these give more decided spectra than the less volatile precious metals, and some interesting results were noticed. Approximate illustrations of some of these spectra are appended.

Spectra of Volatile Metals



Quantitative Spectra of Gold-Copper Alloy.



A very curious fact is apparent in all these spectra, viz., the *unequal lengths* of the spectral lines. Some of the lines of bismuth, for example, are seen to extend nearly across the field of vision, while others appear as mere points upon the edge. Mr. Lockyer has published some most interesting investigations upon the subject of these "long and short lines."

Proceeding to the examination of gold alloys, and starting with base poles,—making the lower pole 250 fine and the upper pole 500 fine,—the gold lines from the upper half were both longer and brighter. Now substituting in place of the 250 pole one 700 fine, the lower half showed the brighter gold lines. Then, changing the 500 pole for one 800, the brightness of the gold line was again reversed. This alternating effect may be continued, decreasing in degree as the fineness of the poles approach more nearly together, until both poles are of the same fineness, when the lines will be equal in length and intensity.

These experiments proved satisfactorily that comparatively wide variations in the composition of gold alloys were discernible. A series of graduated alloys, of more approximate fineness, was now prepared at the Mint, viz.—

Gold and Copper.	Gold, Silver, and Copper.
938·0	940·1
917·0	918·7
906·0	866·8
888·3	888·0
883·5	884·1
876·5	883·0

These alloys were carefully prepared, and assayed closely.

With one electrode pure gold and the other 938 fine, the difference between the respective spectra was of course very marked, the copper lines appearing in the one and not in the other. Substituting for the pure gold the alloy 876·5, the difference was still very marked, for, although both gold and copper appeared in each, the copper lines were much brighter and somewhat longer in the baser alloy, while the gold lines were brighter and longer in the finer. But on comparing the alloys 876·5 and 883·5 (reducing the variation to seven-thousandths), it was both a surprise and disappointment to find the visible difference of result but slightly appreciable. And the same with regard to the alloys of 883·5 and 888·3, and the same with other alloys with equal or less comparative variation of fineness. A variation of one-thousandth required an effort of the imagination, as well as of the eye, to detect any difference whatever. And, although the attempt was made to map an apparent difference between alloys varying two-thousandths, it would certainly not have been a safe test on which to base an assay. Frequent repetitions with changes of adjustment were tried, the battery power varying from one to six Bunsen cells, in connection with Leyden jars varying from one very small jar (improvised out of a test-tube) to fifty large jars, representing a metallic superficies of many square feet, with variations of the distance of the electrodes apart, and with and without the use of a condensing lens; but all these failed to give closer results.

It is true that these changes of conditions produced certain variations in the effects observed,—as, for instance, it was noticed that an increase in the Leyden jar surface always lengthened the lines, the distance between the electrodes and all other conditions remaining the same,—while a decrease in the condensing surface had an opposite effect. Thus, to take the extreme cases, with the single small Leyden jar above referred to, and one cell of battery, the lines broke when the electrodes were not more than one-sixteenth of an inch apart, and disappeared entirely on separating the points one-eighth of an inch.

With fifty Leyden jars and six cells of battery it was found impossible to break the lines at all, even by removing the electrodes to the extreme limit of the spark, and in this case new lines also appeared.

Other variations occurred—such as a momentary irregularity in the length and brightness of the lines, under a strong battery power, owing to the unequal action of the spark; a difference in the action of the gold lines dependent upon the nature of the alloy, silver tending to lengthen them more than equal admixture of copper; the length of the lines is also dependent upon the distance between the spark and the slit (when the latter is used without the intervening condensing lens); moreover, the eye itself is liable to become confused by continued comparisons of very slight differences. The above, and other modifications, so far from solving the problem of close work, rather indicated possible sources of error.

Another element of the process suggested itself as likely to render the results uncertain for the practical purpose of assaying, viz., whether the quantity of metal vaporised, and giving the spectrum, is not too infinitesimal to give safe results for a large melt. This would be affected by the least want of homogeneity in the metal. This is a serious

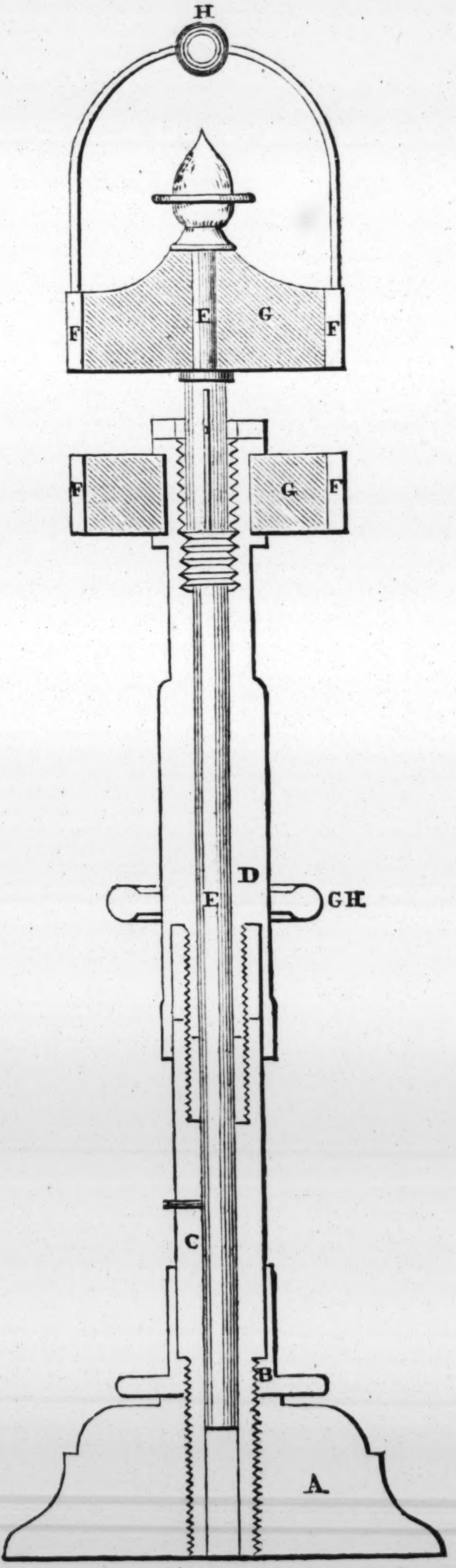


FIG. 4.—ADJUSTABLE ROTARY STAND FOR SPECTROSCOPIC ASSAY.

consideration, and with the view partly to search for unknown sources of error and partly to ascertain generally the quantity of metal operated on in a spectroscopic assay (should that ever be possible) the following experiment was tried:— Having weighed small electrodes, averaging eighteen milligrammes each, with the greatest possible accuracy, on the gold assay balance of the Mint (which is sensitive to a twentieth of a milligramme, or even less), and having arranged a spark register, it was found that 1000 sparks might be passed between these poles, each spark showing the spectrum of the metal distinctly, and yet the loss in weight was too small to be made the base of calculation. Thus, a gold pole lost in weight, after passing 1000 sparks, 1-1000th of a grain; this gives for each spark 1-1,000,000th of a grain of gold, producing a bright spectrum. The number was then increased to 3000 sparks as a test. The loss of weight depends of course upon the electric volume, and in the experiments tabulated an endeavour was made to keep the latter constant. A slight deposit of the vaporised metal from the opposite pole takes place in fine division, but this is easily removed—in the case of copper and gold poles by dipping the gold for a moment in weak acid or by gentle rubbing. The annexed tables, marked A and B, show that the loss in weight is marvellously small, averaging less than seven-tenths of a milligramme of gold for 3000 sparks. To give the amount for each spark, this must be divided by the number of sparks; thus, in round numbers, an electrode loses 1-1000th of a grain after passing 3000 sparks; or for 1000 sparks 1-3000th of a grain, or for each spark 1-1,000,000th of a grain. The exceedingly small quantity of metal thus assayed renders this process, in the writer's opinion, inapplicable to the operations in the Mint; for it is necessary to determine gold assays to the 1-10,000th part of the normal assay weight, and it is hardly conceivable that a discrimination to the 1-10,000th part of the spark assay weight, or the 1-10,000,000,000th of a grain, is practically possible. Even if it were, it would not be proper to assume that a test on such an atomic scale would correctly represent the value of a large deposit, or even of gold ingots. It would certainly not be in the case of silver, which segregates.

The experiments made by Cappel to determine the *minimum* amount of each element that will show a spectrum have been published in tabular form. His method was to volatilise "solutions of the metallic salts between the poles of a small induction coil in Mitscherlich's glass tubes with platinum wicks. A series of solutions, each one half the strength of the preceding one, were prepared from a number of metallic chlorides. The spectrum in connection with the positive pole was continually observed while increasingly concentrated solutions were brought in succession into the action of the spark, until the lines of the substance were clearly visible." If a sceptical mind refuses to believe the results of Cappel, who tells us that 1-600th of a milligramme (1-38,800th of a grain) of nickel will *just* write the signature of that metal, what will he say when, glancing at table B appended hereto, he finds the statement that 1-60,000th of a milligramme (1-3,880,000th of a grain) of nickel will sign its name in *brilliant characters?* And yet the author does not hesitate to say that even a *smaller* amount of this metal will show a spectrum, for it must be remembered that in these experiments a much stronger spark was used than was necessary to show a visible spectrum. When reduced to a minimum, as was done in the case of the miniature Leyden jar, which still gave a distinct spectrum, the loss in weight after 3000 sparks, for silver, copper, and tin, was *absolutely inappreciable* on the balance.

The table of loss shows another curious and unexpected result, viz., that the loss in weight of the volatile metals very slightly exceeds, and in some cases does not equal, the loss of the less volatile metals. Thus, in three different experiments of 3000 sparks each, copper loses but 0·1 milligramme, while gold loses 0·5 milligramme.

An unexplained anomaly was also noticed in relation to the sensitiveness of the spectroscope to the metals present in small proportion. Although Mr. Cappel has shown that 1-4000th of a milligramme of gold will show a spectrum (it is even less than 1-6000th of a milligramme, according to an experiment performed by the method described above) yet a comparatively large proportion of gold may be present in an alloy, the presence of which will not be indicated at all by the spectroscope.

In a slip composed thus—Silver 708 parts, copper 254 parts, gold 38 parts—the spectra of *silver* and *copper* are alone visible.

In fact, in a base alloy of gold and copper containing from 20 to 25 per cent of gold, the gold spectrum is barely visible; while in a fine alloy of gold and copper it was found that 1 per cent of the latter suffices to show the copper spectrum. Also in an alloy of nickel and copper containing 25 per cent of nickel, its spectrum is scarcely visible. Its seems evident, therefore, that the spark selects the more volatile metal as its vehicle.

If the spectroscope fails to reveal the presence of anything less than 200 parts of gold in a base alloy, even a theorist must admit that one could scarcely expect to be able to discriminate with certainty a variation of 1-10,000th in a fine alloy.

For the foregoing reasons, the conclusion seems inevitable, that in the state of spectroscopic science as it now exists, assaying by means of spectrum analysis is, for the present, impracticable for the purpose of Mint operations.

Although these experiments have resulted negatively from the utilitarian standpoint from which they were undertaken, it is hoped that they may prove not altogether without value in a more general point of view. The fact that quantitative proportions of composite substances may be recognised at all, even to a rough degree, cannot but be regarded as a first step. All observations bearing upon the action of the spectral lines in indicating such proportions are at least worthy of being recorded. Not the least curious of these incidental observations is the fact that while the spectroscope is sensitive to the minutest fraction of a grain of gold in the pure state or in solution, it fails to reveal the presence of a much larger proportion in a base alloy. Another is the fact that while the spark appears to select for its vehicle of transmission the more volatile metal in an alloy, and would thus seem to vaporise a greater quantity of the volatile than of the non-volatile component, yet, in point of fact, the loss of weight by such volatilisation is in some instances much less in the former case than in the latter.

The *rationale* of these apparent paradoxes is not at present evident, but if we may judge by former experiences in which problems even more mysterious have been resolved by study, we are warranted in anticipating that when a large number of observations, to be made perhaps by many experimenters groping in the dark, shall be collated, the true scent may of a sudden be struck which shall discover the desideratum of quantitative spectrum analysis.

TABLES.

The *first* column shows the weight of the metallic electrodes in milligrammes before passing the sparks. *Second* column shows the weight after passing 3000 sparks. *Third* column shows the *total* weight of metal volatilised (in fractions of a milligramme). *Fourth* column shows the amount of metal volatilised by *each* spark (in fractions of a milligramme). *Fifth* column shows the amount of metal volatilised by each spark in fractions of a grain troy.

Table A.

			1.	2.	3.	4.	5.
*Upper Pole	..	Gold	16·6	15·9	0·7	1-4286	1-277000
Lower ,,	..	,,	16·7	16·0	0·7	,,	,,
Upper ,,	..	Copper	18·5	18·4	0·1	1-30000	1-1940000
Lower ,,	..	,,	,,	,,	0·1	,,	,,
Upper ,,	..	Gold Ingot	24·0	23·4	0·6	1-5000	1-324000
Lower ,,	..	,, ,,	,,	,,	0·6	,,	,,
Upper ,,	..	Tin	20·0	19·6	0·4	1-7500	1-486000
Lower ,,	..	,,	,,	19·4	0·6	1-5000	1-324000
Upper ,,	..	Silver	24·8	24·6	0·2	1-15000	1-976000
Lower ,,	..	,,	25·1	25·0	0·1	1-30000	1-1940000
†Average ..	..	Lead	91·6	90·0	1·6	1-1870	1-121000

Table B.

Upper Pole	..	Gold	20·5	20·0	0·5	1-6000	1-388000
Lower ,,	..	Copper	10·0	9·9	0·1	1-30000	1-1940000
Upper ,,	..	Gold Ingot	21·0	20·4	0·6	1-5000	1-324000
Lower ,,	..	Copper	20·2	20·0	0·2	1-15000	1-976000
Upper ,,	..	Silver	6·0	5·8	0·2	1-15000	,,
Lower ,,	..	Tin	20·0	19·4	0·6	1-5000	1-324000
‡Upper ,,	..	Nickel	12·0	11·95	0·05	1-60000	1-3880000
Lower ,,	..	,,	12·0	11·9	0·1	1-30000	1-1940000

* The upper pole usually formed the positive electrode.

+ The average of lead is given because the results varied in different experiments.

‡ The *minimum* of metallic nickel producing a spectrum according to Cappel's tables is one six-hundredth of a milligramme.

NOTICES OF BOOKS.

Outlines of Cosmic Philosophy, based on the Doctrine of Evolution, with Criticisms on the Positive Philosophy. By John Fiske, M.A., LL.B., Assistant Librarian and formerly Lecturer on Philosophy at Harvard University. London: Macmillan and Co. 1874.

The groundwork of the present volumes appeared in 1869 and 1871, in the form of a Course of Lectures delivered at Harvard University, and afterwards in London, Boston, and New York. The work is a detailed treatment of Mr. Herbert Spencer's "New Philosophy," and it contains further criticisms of the Positive Philosophy, and some new matter relating to the evolution of society, and the conditions of human progress. The author commences by showing the relativity of all knowledge; we cannot know the absolute, only the relative, for "we cannot know things as they exist independently of our intelligence, but only as they exist in relation to our intelligence;" and, secondly (and this assertion we commend to all free-thinkers and materialists), "the possibilities of thought are not identical or co-extensive with the possibilities of things." If this were recognised more fully, how much less should we hear of those unfortunate conflicts between Religion and Science, of which we have heard a great deal too much of late. Led a step further, we have to realise that *all knowing is classifying;* that when we note any natural phenomenon, for example, and believe it to be explained, we have simply correlated it with other phenomena which it resembles. The elements of likeness, difference, and relation, enter into and limit all our cognition. The second chapter (on "The Scope of Philosophy") may be summed up in the following words:—"Common knowledge expresses in a single formula a particular truth respecting a particular group of phenomena; Science expresses in a single formula a general truth respecting an entire order of phenomena; Philosophy expresses in a single formula a universal truth respecting the whole world of phenomena. Philosophy therefore remains, as of old, the study of the Cosmos,—save that is the study of phenomena not of noumena, of evolution not of creation, of laws not of purposes, of the How? not of the Why?" The third chapter discusses the "Test of Truth;" and at the outset we meet with a very concise definition of truth, although described as only "provisionally defined:"—"Truth may be provisionally defined as the exact correspondence between the subjective order of our conceptions and the objective order of the relations among things." Concerning the methods of Philosophy, the author distinguishes between the subjective and the objective methods; the former belonging to metaphysical philosophy, which vainly attempts to frame plausible hypotheses concerning objectives by purely subjective means; the latter belonging to the Cosmic philosophy, which attempts to collect into a universal body of truth the generalisations obtained by Science, and thus adopts the method of Science, the objective method. Metaphysics is well distinguished from Physics in the fifth chapter:—"A scientific explanation is a hypothesis which admits of verification,—it can be either proved or disproved; while a metaphysical explanation is a hypothesis which does not admit of verification,—it can neither be proved or disproved." Thus our author considers Newton's hypothesis of gravitation, and Descartes's hypothesis of vortices, as strictly scientific; for the first admitted of proof, and the latter of disproof; while Stahl's hypothesis of a vital principle was purely metaphysical, for it admitted of neither.

In the chapter on "Anthropomorphism and Cosmism" Dr. Fiske has some very pertinent remarks concerning the apparent antagonism between Science and Religion, "the abiding terror of timid or superficial minds:"—"While Atheism scoffed at religion, and denied that the religious sentiment needed satisfaction; while Positivism, leaving no place in its scheme for religion to occupy, was compelled by an afterthought to proclaim that the religious sentiment finds its legitimate satisfaction in the service of an idealised Humanity; Cosmism, on the contrary, assigns to religion the same place which it has always occupied, and affirms that the religious sentiment must find satisfaction in the future as in the past, in the recognition of a Power which is beyond Humanity, and upon which Humanity depends. The existence of God—denied by Atheism and ignored by Positivism—is the fundamental postulate upon which Cosmism bases its synthesis of scientific truths. The infinite and absolute power which Anthropomorphism has in countless ways sought to define and limit by metaphysical formulæ, thereby rendering it finite and relative, is the power which Cosmism refrains from defining and limiting by metaphysical formulæ, thereby acknowledging—so far as the exigencies of human speaking and thinking will allow—that it is infinite and absolute. Thus, in the progress from Anthropomorphism to Cosmism, the religious attitude remains unchanged from the beginning to the end." We do not remember to have seen this view put in more forcible and just language.

In the chapter on the "Classification of the Sciences" we are told that Astronomy was a science in the days of Hipparchos; Physics became a science when Galileo discovered the laws of falling bodies; Chemistry, when Lavoisier disproved the theory of phlogiston and explained the true principles of combustion;

Biology, when Bichat indicated the relations existing between the functions of organs and the properties of tissues; while Sociology has at present become a science. The following complete classification of the sciences is finally adopted:—

Abstract Sciences, Dealing with *relations*, that are—	Qualitative	Logic.
	Quantitative	Mathematics.
Abstract-Concrete Sciences, Dealing with *properties*, that are manifested—	In movements of masses ..	Molar Physics.
	In movements of molecules, and in aggregations of molecules that are homogeneous	Molecular Physics.
	In aggregations of molecules that are heterogeneous ..	Chemistry.
Concrete Sciences, Dealing with *aggregates* (with their properties and relations), as actually exemplified—	In stellar and planetary systems	Astronomy.
	In the earth	Geology.
	In living organisms	Biology.
	In the functions which adjust organic actions to specific relations in the environment	Psychology.
	In the mutual relations of living organisms grouped into communities	Sociology.

Dr. Fiske concludes the first part of his book by asserting that "the law of evolution is the first generalisation concerning the concrete universe as a whole, which has been framed in conscious conformity to the rigorous requirements of the objective method, and which has therefore served to realise the prophetic dream of Bacon, by presenting Philosophy as an organism of which the various sciences are members." And, finally, he fuses into one sentence the two thoughts (of Plato and of D'Alembert) which he places on the title-page of the work:—"To a thinker capable of comprehending it from a single point of view, the universe would present but a single fact, but one all comprehensive truth; and it is for this reason that we call it Cosmos, and not Chaos."

Part 1 (Prolegomena) is followed by Part 2 (Synthesis). At the basis of the physical sciences lie two universal propositions, or, as we should prefer to call them, axioms:—*Matter is indestructible* is the one, *Motion is continuous* is the other. "The fundamental elements of our conception of matter are its force-element and its space-element, namely, resistance and extension. The fundamental elements of our conception of motion are its force-element and its space- and time-element, namely, energy and velocity. That in each case the force-element is primordial is shown by the facts that what we cannot conceive as diminished by the compression of matter is not its extension, but its power of resistance; what we cannot conceive as diminished by the retardation of motion is not its velocity, but its energy." In the fourth chapter (on the "Law of Evolution") we find some curious and most interesting remarks on the relative condition of the molecules of carbon, hydrogen, oxygen, nitrogen, in organic bodies. It is shown how the molecules of the first-named element are far less mobile than those of the others, since solid carbon has never been expanded into the liquid form by the application of the most intense heat, while the gases hydrogen, oxygen, nitrogen, have never been condensed into the liquid form by the application of the most intense cold, accompanied by extremely high pressures. The fifth chapter contains a very graphic and comprehensive account of planetary evolution and the nebular hypothesis. The next chapter treats of the "Evolution of the Earth." In discussing the conditions of thought and consciousness, the author mentions that consciousness cannot continue for an instant unless oxygen is in contact with the grey tissue of the cerebrum; that mental exertion bears a "marked ratio" to the weight of the brain, and to the amount of phosphorus contained in it; and, finally, that the amount of heat evolved by the cerebrum during the act of thinking varies with the amount of mental activity which is taking place.

The doctrine of Natural Selection is very fully discussed, and the chances in favour of its being a true explanation are declared to be as many thousand millions to one. When this theory is analysed it is found to consist of eleven propositions, which may be enumerated as follows:—

"1. More organisms perish than survive.
2. No two individuals are exactly alike.
3. Individual peculiarities are transmissible to offspring.
4. Individuals whose peculiarities bring them into closest adaptation with their environment are those which survive and transmit their peculiar organisations.
5. The survival of the fittest thus tends to maintain an equilibrium between organisms and their environments.
6. But the environment of every group of organisms is steadily, though slowly, changing.
7. Every group of organisms must accordingly change in average character, under penalty of extinction.
8. Changes due to individual variation are complicated by the law that a change set up in any one part of a highly complex and coherent aggregate, like an organism, initiates changes in other parts.
9. They are further complicated by the law that structures are nourished in proportion to their use.
10. From the foregoing nine propositions, each one of which is indisputably true, it is an inevitable corollary that changes thus set up and complicated must eventually alter the specific character of any given group of organisms.

11. It is postulated that, since the first appearance of life upon the earth's surface, sufficient time has elapsed to have enabled such causes to produce all the specific heterogeneity now witnessed."

In a long chapter devoted to "The Composition of Mind" the author arrives at the conclusion that the mind has grown in strength and complexity as the nervous system has grown in definiteness and coherence. Next he traces the evolution of mind, and in discussing this he clearly points out that the operations of thought profoundly modify the structure of the brain, even in the course of a few years. The brain sometimes increases in structural complexity till the end of life, and often for many years after the age of 25. The brains of five very eminent men, examined by Wagner, were found to possess extraordinary complexities of structure,—ridgings, and furrowings, and deep irregular fissures. We are told, further, that the cerebrum and cerebellum are the organs in which ideal feelings and thoughts are generated, and that they are made up of tissues which undergo chemical changes with great rapidity. Exception is taken to Locke's comparison of an infant's mind to a blank sheet of paper, upon which experience writes knowledge: our author prefers to regard the infant's mind as a sheet written over with invisible ink, which is made visible by the developer of experience. The remaining chapters of the second volume—on the Evolution of Society, the Conditions of Progress, the Intellectual and Moral Genesis of Man, Matter and Spirit, &c.,—indicate a vast amount of reading, and a judicial examination of the more important now before the world.

The whole work is intensely suggestive, both to the man of science and to the metaphysician. The author has worked up into a homogeneous whole the more prominent views of Herbert Spencer, Freeman, Buckle, Bain, and has added somewhat of his own. To those who wish to be *au courant* with advanced modern thought, from Darwinism to Sociology, from the mechanical theory of heat to the nebular hypothesis, the book will be a great boon. No man of science can read it without profit. The facts are grouped together in a clear logical manner, and although some of the definitions appear to us to be quite unnecessarily complex, the book cannot be said to be overloaded by metaphysical technicalities.

A Treatise on Magnetism, General and Terrestrial. By HUMPHREY LLOYD, D.D., D.C.L., Provost of Trinity College, Dublin, formerly Professor of Natural Philosophy in the University. London: Longmans, Green, and Co. 1874.

THE author begins his treatise by giving an account of the general phenomena of magnetism, the processes of magnetisation, and the measurement of magnetic force. He then passes on to the magnetism of all bodies, discovered by Faraday in 1845, and extended by Knoblaud, Tyndall, and others. It is curious, however, that the fact that a piece of bismuth repels a magnetic needle was remarked no less than a century ago by Brugmans, while Lebaillif made the same observation with regard to antimony in 1829. From the experiments of Tyndall and Weber we may conclude—

"1. That all bodies are *polarised* under the action of a magnetic force.
2. That in soft iron, and other *para-magnetic* bodies, the pole induced in the side next the inducing pole is of a *contrary* kind, and that, consequently, the body is *attracted*.
3. That in bismuth, and other *dia-magnetic* bodies, the pole induced on the near side is of the same nature as the inducing pole, and that, therefore, the body is *repelled*."

Becquerel has found that the specific magnetism of manganese is such as would result from the presence of 1-100oth part of its weight of iron, while that of gold would result from the presence of 1-114000th part of its weight of iron; but this latter statement is not very clear, since we find gold given in the list of dia-magnetic bodies. The table of results given on p. 63 is of special interest. It shows the quantitative relationship between various bodies chiefly dia-magnetic (–), with a few magnetic gases (+), in regard to absolute force acting on equal volumes and reduced to a vacuum. From this we learn that while oxygen is +17·5, nitrogen is almost neutral on the side of attraction +0·3, carbonic acid is quite neutral, and hydrogen almost neutral on the side of repulsion, –0·1. Water rises to –96·6, sulphur to –118·0, and bismuth—the most dia-magnetic body of all—to –1967·6.

The positions of the four magnetic poles, the existence of which was inferred by Halley, are given as follows, the determinations being those of Prof. Hausteen:—

		Latitude.	Longitude.
Stronger North Pole	...	70° 5′ N.	99° 6′ W.
Weaker North Pole	...	85° 21′ N.	118° 39′ E.
Stronger South Pole	...	69° 26′ S.	138° 35′ E.
Weaker South Pole	...	77° 17′ S.	120° 57′ W.

A detailed account is given of the various elements of the earth's magnetism, and the methods of observing them. The book would be improved by good drawings of the various instruments now employed in magnetic observations. Some useful Curve Tables are given. The whole subject is treated mathematically, and the book is a valuable contribution to our magnetic literature. It will be especially useful to observers and workers in the numerous magnetic observatories which are now to be found in every part of the world.

The Common Frog. By St. George Mivart, F.R.S. &c. London: Macmillan and Co.

We love the frog, not merely when daintily dressed and served up at table,* but when enjoying life in his native pool. It is pleasant to watch him on a calm sunny day, as he rests embowered amidst reeds and water lilies, with his eyes just above the surface, contemplating the world with full approval, and to hear him now and again give vent to his feelings in a gentle murmur, all unlike his nocturnal chorus. Our friend's habit of rising to the surface of the water in fine weather, and of remaining at the bottom in gloom and storm, was known and noticed by Aristophanes, who represents him as saying—

> "When the sun rides in glory, and makes a bright day,
> 'Midst lilies and plants of the water I stray;
> But when the sky darkens with tempest and rain,
> I sink, like a pearl, in my watery domain."

The barometric propensity of the frog is often utilized on the Continent. A tall glass jar is filled with water, and fitted up with a miniature flight of stairs, and in it is imprisoned a frog—very often the pretty green tree-frog. Those who have carefully observed the movements of the little captive, can thence deduce weather forecasts quite as trustworthy as those furnished by the barometer. Mr. Mivart, indeed, awards to the frog the title "the martyr of science." "The frog," says he, "is the never-failing resource for the physiological experimenter. It would take long indeed to tell the sufferings of much-enduring frogs in the cause of science. What! frogs can do without their heads? What! their legs can do without their bodies? What! their arms can do without either head or trunk? What is the effect of the removal of their brains? How can they manage without their eyes, and without their ears? What effects result from all kinds of local imitations, from chokings, from poisonings, from mutilations the most varied? These are the questions again and again addressed to the little animal."

But, after all, the frog has less to fear from science than from brutish ignorance.

> "Whene'er we take our walks abroad,
> How many frogs we see"—

not to speak of toads and efts—which have evidently been wantonly tortured to death. Yet, like his nearest allies, the frog, far from being hurtful, is the friend of man. "It feeds," says Mr. Mivart, "exclusively upon living animals, such as insects and slugs, which it catches by suddenly throwing forwards beyond the mouth the free *hinder* part of the tongue (furnished with an adhesive secretion), and then retracting it, with its prey, in a most rapid manner." This style of hunting is carried on by the common frog upon the ground, and by the tree-frog up among the branches; the only misfortune being that not merely vermin, but rare and lovely species, which to capture gladdens the heart of the entomologist, thus come to an inglorious end. It is, by the way, a remarkable fact that the tree-frog, spread over all parts of Europe, and far from uncommon in the north of France and in the Channel Islands, is not found in Britain. Our climate certainly opposes no obstacle to his existence and multiplication, and suitable food he could find in plenty. His natural enemies are not more numerous in England than in France or Germany. What cause, then, can have led to his extinction since Britain was severed from the Continent? Or has he only appeared in Western Europe since that event. A similar fact, noticed by the author, is the absence of the land eft, or salamander. We are compelled, however, to differ from Mr. Mivart when he pronounces this animal common throughout Europe. In the more eastern parts of the Continent it is strictly local, being found in the greatest plenty in the Valley of the Neisse, between Ostritz and Hirschfelde. Yet we have in Devonshire, Wales, and Cumberland, localities so similar in character that we may wonder why this harmless, though dreaded,* creature is a stranger to our island.

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* We can vouch for the fact that the common frog, if a shade less delicate than the "Cambridgeshire nightingale," is yet, when properly prepared "choicely good."

The following passage will, perhaps, lead some persons to salutary reflection:—"Many persons are accustomed to make much of the distinctive peculiarities of the human frame. In fact, however, man's bodily structure is far less exceptional in the animal series, is far less peculiar and isolated, than that which is common to frogs and toads."

To minds of a higher degree of culture, the following sentences will prove even more suggestive:—"For some years, individuals of this species (the axolotl of Mexico) have been preserved in the Jardin des Plantes, at Paris, and a few years ago one individual amongst others there kept, was observed, to the astonishment of its guardians, to have transformed itself into a creature of quite another genus—the genus *Amblystoma*,—one rich in American species. Since then several other individuals have transformed themselves, but without affording any clue as to the conditions which determine this change—a change remarkable indeed, resulting, as it does, not merely in the loss of gills and the closing up of the gill openings, but in great changes with respect to the skull, the dentition, and other important structures.

"There is, moreover, another and very singular fact connected with this transformation. It is that no one of the individuals transformed (although we must suppose that by such transformation it has attained its highest development and perfection) has ever yet reproduced its kind, and this in spite of every effort made to promote reproduction by diet, and as to putting together males and females both transformed, also transformed males with females untransformed, and males untransformed with females transformed. Indeed, the sexual organs seem even to become atrophied in these transformed individuals. Moreover, all this time the untransformed individuals have gone on bringing forth young with the utmost fecundity."

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* An officious gensd'arm on the frontier of Bohemia who insisted on overhauling our collecting boxes, fled in terror, calling upon St. Nepomuc to protect him when he saw a cargo of salamanders.

We do not know of any modern observation more calculated to stagger a naturalist of the old school. The power of reproduction in every species was heretofore regarded as necessarily correlated with the highest development and full maturity. Here, on the contrary, we see such power left behind as a species advances to perfection.

The author suggests the possibility that the genus *Menobranchus* may be a "persistent larval form, and which now never attains its adult state." These considerations have an important bearing both upon the genesis and the extinction of species. The reader will not fail to remark that a current of what some will call anti-Darwinism pervades the whole work. In how far either the author or Mr. Darwin is in the right, and whether either of them has done more than apprehend some phases of a truth not yet revealed to us in its entirety, we shall not presume to determine. But we must point out that Mr. Mivart's polemic is strictly scientific, and, therefore, legitimate, based as it is on a searching morphological and physiological analysis of organic forms, and on a review of their mutual relations. It differs *toto cœlo* from the rhetorical and sentimental anti-Darwinian diatribes which pass current in the pulpit, on the platforms of young mens' institutes, and in commercial rooms, and which consists in little more than appeals to vulgar prejudice by a speaker whose tongue runs the more freely the less he knows of his subject.

Mr. Mivart has produced a work which may be read with pleasure and instruction by any person of decent education, and which at the same time will prove suggestive to the few who make the philosophy of organic life their special study.

It is an able monograph of the frog, and something more. It throws valuable cross-lights over wide portions of animated nature. Would that such works were more plentiful.

A Glossary of Fossil Mammalia. By J. E. Gore, Assoc. Inst. C.E. Roorkee: Thomason College Press.

In this tiny volume of fifty-one pages, the author gives a "list of fossil mammals, compiled for the use of students." The classification adopted is neither geological—according to the formations in which the remains have been found—nor zoological—according to their structural affinities—but alphabetical. The descriptions are necessarily of the briefest, and the localities are sometimes extremely vague, as, *e.g.*, "South America," "North America," &c. Controversial points are, in general, avoided, though the author thinks it "impossible to imagine how all the different races of mankind could have descended from one pair of ancestors in the comparatively short period of 6000 years." The extreme conciseness of the book has certainly one advantage: circumstances which might have been lost to the reader amidst copious descriptions, stand out here in startling relief. Among these we may mention the very small number of mammalian forms whose remains have hitherto been discovered. Where so much has evidently disappeared, no valid argument can be built upon the non-occurrence of any particular type, *e.g.*, an anthropoid intervening between the lowest man now known and the highest ape. In apes our fossil fauna is remarkably poor. Yet among the comparatively few forms which have reached us, how many are evidently "connecting links" between groups now existing in isolation.

We cannot help asking whether the work would not have been more useful to the student had the author extended his plan so as to include all the vertebrates? Even then it would have been far from bulky. For the purposes mentioned in the preface the work will doubtless be useful.

Sulphur in Iceland. By C. CARTER BLAKE, D. Sc. London: E. and F. N. Spon.

THE importance of sulphur in industrial chemistry can scarcely be conceived by the outside public. Perhaps if we say it plays a part in the chemical arts something analogous to that of iron in mechanical operations, we may give some idea of its value. In its uncombined, elementary state, it is largely used in the manufacture of gunpowder. Burnt in the air, and thus converted into sulphurous acid, it serves to bleach woollen goods and straw. But it is in the form of sulphuric acid, when combined with the largest possible amount of oxygen, that its applications are widest and most important. It enables us to decompose common salt, and thus to obtain a series of products, of which soda-ash, caustic soda, soda crystals, bicarbonate of soda, hydrochloric acid, bleaching-powder, soap, and glass, are the most prominent. By its aid we act upon certain insoluble minerals, such as coprolite and apatite, and convert them into valuable manures, or obtain from them phosphorus, essential to the match-trade. In numerous chemical processes we require, it is true, other mineral acids, such as the nitric and hydrofluoric; but before we can obtain these in a separate state we must first have sulphuric acid, which, as the great master-key to Nature's treasure-houses, sets them free from inert combinations. If we wish to obtain alum, which has many honest uses besides the questionable part it is made to play in the hands of the baker, we have again recourse to sulphuric acid. The very vegetable acids, such as the oxalic, generally require its aid before they can appear in a state of purity. In refining fats and oils it plays a prominent part. If we turn to the tinctorial arts, we find the dyer using this same acid at almost every stage. In short, we may say that, from the vastest operations of the manufacturer to the most delicate and minute procedures of the analyst, sulphur, directly or indirectly, is everywhere present.

The supply of sulphur becomes, in consequence, a question of national importance. Hitherto we have obtained it from Sicily, from Spain, and even from Mexico. The Mexican deposits labour, naturally, under the drawback of inconvenient distance. The sources in the Mediterranean countries, if not actually approaching exhaustion, have been very largely drawn upon, and the prices are hence high, with the probability of an increase. Thus, according to authentic information, Sicilian sulphur costs on the spot, £3 16s. 10d. per ton, and by the time it reaches England, its price has risen to £5 17s. 4d. At the same time there exist few richer deposits of sulphur capable of being worked at a less cost and much nearer to our own coasts. Iceland possesses sulphur-beds, compared to which those of Sicily are insignificant. The mineral lies on the surface, and requires merely digging, whilst in Sicily mining to the depth of 40 to 60 feet is required. At an outside estimate, Iceland sulphur can be delivered in any English port at £3 per ton. It appears that there are in Iceland two principal sulphur regions—that of Krisuvik, in the south-west, and that of Lake Myvatn, in the north-east of the island. A dispute appears to have arisen as to the comparative advantages offered by these two localities. Mr. Vincent, in a paper read before the Society of Arts, on the 15th of January, 1873, appears to have come forward as the advocate of the Krisuvik deposits, and to have indulged in some geological speculations which have at least the merit of singularity. Dr. Blake, in the pamphlet before us, proves, on the most indubitable testimony, the superiority of Lake Myvatn and its district as a source of sulphur, and exposes the geological dreams and geographical errors of his opponent in a very outspoken manner.

To us it seems important mainly that the resources of that wonderful island should be developed, alike to its own benefit and to that of our chemical manufacturers. If Mr. Vincent and his friends think Krisuvik the best locality, there is no reason why they should not go to work accordingly. Dr. Blake's treatise will do good service in drawing the attention of English capitalists to a region where such vast stores of wealth have been hitherto lying useless.

Elements of Physical Manipulation. By EDWARD C. PICKERING. Part I. London: Macmillan and Co.

TREATISES on chemical manipulation have been given to the world by Faraday and Mr. G. Williams, not to speak of the instructions on the subject appended to works on chemical analysis. But a systematic manual of physical manipulation has hitherto been a desideratum. The boundaries of the two subjects are not, indeed, very easily drawn. As the author remarks, "the object of all physical investigation is to determine the effects of certain natural forces, such as gravity, cohesion, heat, light, and electricity." Now, among the effects of heat, light, and electricity, chemical changes in the bodies acted upon form a very important part. Thus chemical and physical manipulation must be to a certain extent identical. The chemist is obliged to take note of many of the physical properties of the substances which come under his hands, and to account for their physical changes. The study of prolonged light is an intimate part of physics, but its action upon certain organic acids, and upon sugars, affords the chemist valuable means for their qualitative detection and quantitative determination. This, as a general truth, was pointed out by Comte, who shows that every science supplies methods, or means of research, for those succeeding it in the scale of increasing complication.

Mr. Pickering begins his work with an exposition of the two methods—the analytical and the graphical—of mathematically representing and examining the results of an experiment. In the former method each quantity is represented by a letter, and the conclusions are then drawn by algebraic methods and the calculus. The graphical method represents quantities by lines or distances, with a view to their geometrical treatment. The former method, as the author justly remarks, is the more accurate, and would be generally preferable were it not for accidental errors, and were every physical law capable of representation by a simple equation. The graphic method, on the other hand, has the advantage of speed, and enables the accuracy of results to be seen at a glance.

The author next proceeds to give instructions for physical measurements—the determination of time, weight, and distance. Of these considerations, the first and last, though playing hitherto no appreciable part in chemistry, are in physics of the highest importance.

Under the head "general experiments," we find valuable remarks on the estimation of tenths, on verniers, on the insertion of cross-hairs; suspension by silk fibres; temperature curve; testing thermometers; eccentricity of graduated circles; contour lines; cleaning mercury; calibration by mercury; calibration by water; the cathetomer; the hook gauge; the spherometer; estimation of tenths of a second; rating chronometers; making weights: method of weighing; decanting gases, and their reduction to standard temperature and pressure; standards of volume; reading microscopes; the dividing engine, and ruling scales.

Successive sections then treat of the mechanics of solids; the mechanics of liquids and gases; sound, and light.

We strongly recommend this work to all physical students; and we will even say, that now so much attention is directed to subjects where physics and chemistry inosculate, its careful study will be useful to chemists. This is especially the case with the section on light. A second volume is announced, dealing with light and electricity.

The Chemistry of Fermentation in the Process of Bread Making. By T. KARR CALLARD. London: Elliott Stock.

THE author of this pamphlet does not accept the "fungoid theory" of yeast. He holds that the "yeast cells are simply vesicles of carbonic acid gas entangled in the elastic gluten;" and the growth of yeast he considers as "nothing more than the conversion of fresh gluten into its own condition." What, then, effects the conversion? The constituents of bread, we are told, are "flour, yeast, potatoes, salt, and water." The mention of potatoes would certainly have astonished our forefathers, and at the present day will astonish those numerous families in the north of England who bake for their own consumption, and who, be it remarked, produce bread less white and "fluffy" than that of the London bakers, but sweeter, more digestible, and free from the tendency to turn sour. The use of potatoes in baking is certainly legalised by Act of Parliament, and cannot, therefore, be technically called an adulteration. That it is necessary the experience of generations has abundantly disproved. We are also told that flour containing little gluten is superior to samples in which this constituent is more plentiful! As a rule, we know that the wheats of cold climates are poor in nitrogenous matter, whilst those of Algeria, Hungary, Italy, and the Black Sea districts are rich. African wheat may contain twice as much gluten as Scotch. We grant that the last-mentioned may yield whiter bread, but we protest against colour being accepted as the standard of merit in any article of food, in place of flavour and nutritive power. A certain amount of starch is doubtlessly needed to dilute the gluten, and facilitate the process of bread making, but the latter is the blood-forming constituent.

The author's condemnation of the Kuhlman process for the detection of alum in bread is perfectly just. But if it ever has been "in the highest esteem" among chemists, it certainly is not so at present. To turn to alumina and sulphuric acid possibly present in salt as a means of explaining the occurrence of alum in bread, seems to us rather far-fetched.

We share the author's regrets that any baker should have been—as it is intimated—convicted wrongfully; but still more do we regret that hundreds should have used alum and other sophistications all their lives, and should have escaped.

Transactions of the Royal Society of Victoria. Vol. X., February, 1874. Melbourne: Stilwell and Knight.

It is satisfactory to see that the cultivation of science is not entirely overlooked by the "Greater Britains" of the southern ocean. The present volume makes its appearance under peculiar auspices. A certain Government grant had been withdrawn in 1868, and since that time there had been no funds to issue any transactions, or even to pay for the printing of the volume which had last appeared.

We are not quite satisfied with this explanation. We certainly hold that it is good policy on the part of Governments—as those of Germany are, and have long been, doing—to give every facility for the cultivation of science. We believe that museums, libraries, observatories, laboratories, founded and upheld at the national expense, will prove an excellent investment. But, in default of Government aid, great things may be accomplished by private munificence, as we see in the United States. It is scarcely creditable that so flourishing, energetic, and wealthy a community as Victoria should allow the transactions of its chief learned society to lie unpublished for want of funds!

The local administration has, it seems, repented at last of its mistaken parsimony, and the present volume has been prepared —under difficulties. Some of the papers, we are told, are altogether wanting; several have been returned to their authors: and some are not recoverable. We are happy to learn that there is "a prospect of greater regularity in the issue of the transactions for the future."

Sanitary regulations, or rather their necessity, appear to be engaging much attention at Melbourne. In addition to a paper on the "Decay of Gaspipes in Certain Soils," one on "Street

Odours, and Neglect of Ventilation (which appears to have been lost), and one on the "Yan-Yean Water Supply" (which has shared the same fate), we meet with an interesting essay by S. W. Gibbons, F.C.S., on "Air and Water Poisoning in Melbourne." The sanitary state of this rising city is not to be rejoiced over. In the gutters flows a liquid which is "simply sewage, differing only in age from that which flows in London sewers. Our sewer is on the roadway instead of under it, and the contents are carried off more rapidly. Moreover, the gases it evolves, instead of being confined in covered drains, and smelt only through occasional gratings, are here diffused in the atmosphere, to be breathed by the residents and passers-by, and only observed when they are more than usually noisome, as in Bourke and Swanston Streets, at night. Then it is ready-made pestilence." Mr. Gibbons has made careful microscopical examinations of the water from the street-gutters, and the results quite confirm the foregoing general description. The people of Melbourne, it appears, have the pleasant habit of flushing their cesspools *into the street!* These same cesspools appear to be constructed in a more offensive and dangerous manner even than we have them in England. "In a very illustrative case that lately came under my notice," says Mr. Gibbons, "the floor of the closet which joined the house was *two feet above that of the front parlour.* It was only emptied when the contents neared the floor. The fermented urine had eaten its way through the cesspit walls, and had saturated the ground under the house." To appreciate fully this state of things, we must remember that the average temperature is about 10° F. higher than that of England, and the supply of water decidedly less.

Passing to other subjects we cannot help noticing with regret that chemistry finds apparently few votaries at the antipodes. Of the fifty-five papers given in the index, not one can rank under the head of chemical research, and even technological chemistry and metallurgy are very meagrely represented. Not less do we deplore the absence of geological, zoological, and botanical research. In a country so imperfectly explored as is Australia, we should think that men of an observant turn of mind would feel themselves irresistibly drawn to such studies, and that a rich harvest of recorded facts would be the result. The quantity of work which has to be done before the organic geography of Australia is even tolerably complete, and before even a superficial oversight of its palæontology is acquired, is perfectly immense. How comes it that a body like the Royal Society of Victoria takes so little interest in what may be called its natural task?

"The Classificatory System of Kinship," by the Rev. Lorimer Fison, is a most interesting investigation into the social arrangements of savage man in pre-historic times. It would be impossible within our limits to give any just idea of its contents, but we hope that so valuable a contribution to ethnology will appear in some form accessible to the English public.

A paper on "Matter, a Mode of Motion," ranks, unfortunately, among the missing.

La Pluie et le Beau Temps. Par PAUL LAURENCIN. Paris: J. ROTHSCHILD.

THE appearance of this book might be taken as a sign that an interest in the state of the weather, sometimes considered as an English national peculiarity, has spread to our neighbours across the Channel. M. Laurencin has given the public a popular and handy manual of meteorology. He treats of the atmosphere, atmospheric heat, atmospheric currents, atmospheric moisture; rain, with its good and evil effects; storms, cyclones; the rainbow; fine weather; climates; the seasons; prevision of the weather; the moon; observatories; and the sanitary effects of rain and fine weather.

On all these subjects he gives in a pleasant, chatty manner, a great amount of information in which even the educated classes are often found wanting. A curious feature of the work is the quaint old proverbs in which the French peasantry have expressed their traditional weather wisdom. Some of these are preferable to their English representatives. We say in this country—

> "A rainbow in the morning
> Is the shepherds' warning;
> A rainbow at night
> Is the shepherds' delight."

Jacques Bon-homme, it appears, is less confident:—

> "Arc-en-ciel du matin
> Pluye sans fin;
> Arc-en-ciel du soir,
> Il faut voir."

A very wise conclusion! The work is abundantly illustrated.

Many of the engravings are essential to a right understanding of the text. But the views of sunrise and sunset, and the cuts of a swallow, a cart-horse, and a cat—the latter evidently in a very bad humour—can scarcely be pronounced either useful or ornamental.

Taken as a whole, we may pronounce this manual no unworthy member of that valuable and interesting series of popular scientific works which during the last few years have issued from the French press.

Les Rochers; Description de leurs Elements; Methode de Determination. Par EDOUARD JANNETAZ. Paris: J. Rothschild.

ELEMENTARY works on geology are plentiful in the languages of all civilised nations, or cultur-völker, as the German phrase goes. These manuals give a description of the various rocks; treat of their occurrence and localities, their chemical components and organic remains; their supposed origin and age, and the changes they are inferred to have undergone from volcanic or from glacial action. But one thing is wanting. The tyro, who does not wish to limit his studies to books, but to become himself a reader of the great stone documents, asks "How am I to distinguish the various species of which you speak?" To this question ordinary geological text-books return no definite answer. The student may go to the localities indicated for any particular formation, and may there study its characteristic features, so as to recognise it on any future occasion. M. Jannetaz, however, endeavours to supply a direct answer to the question, and to give instructions for the determination of rocks.

In the first part of the work we find a description of the "mineral species most important from a lithological point of view," with their chemical, optical, and physical characters, the crystalline form being in most cases shown in a diagram. The second part treats of the rocks themselves, their essential and their secondary or accessory constituents. The section on granite gives a characteristic instance of the manner in which this department is worked out.

Lastly, we come to the "method to be followed in the practical determination of rocks," a portion of which we transcribe, to give the reader an idea of its nature:—

Sect. 1.—*Globular rocks* (p. 226).

I. Globules harder than the point of a graver, p. 226.	A. Vitreous globules.
	B. Crystalline ditto.
	C. Irregular grains, without intervening matter.
	D. Globules forming mamillary masses.
II. Globules softer, p. 228.	1. Effervescing in HCl, and not becoming magnetic on charcoal.
	2. Effervescing in HCl, and becoming magnetic.
	3. Not effervescing, but becoming magnetic.
	4. Not effervescing, and not becoming magnetic.

Each of these heads is then further extended, until the clue followed leads the enquirer to the species sought.

We are perfectly aware that in no department of natural science is there a royal road to identification of species. When systematists have done their best, much will still be left to the patience and the tact of the student. We know that the very boundaries of species, and consequently their number, are points upon which eminent authorities differ. Still, making all needful allowance for such considerations, we consider that M. Jannetaz has, by the production of this little work, done much to smooth the path of the student, and we expect that it will, by facilitating observation, give a new impulse to geological science.

Causeries Scientifiques. Par HENRI DE PARVILLE. 1873. Paris: J. Rothschild.

THIS yearly volume has for its object to give an account of discoveries and inventions—of the progress of science and industrial art. But it does not consist of mere extracts from scientific and technological journals, and from the transactions of learned societies. The scientific novelties and facts are, of course, obtained from a variety of sources, but the description is original. In this manner is produced a whole much more readable than the English "Year-Book of Facts," and justly entitled to the name it bears—"Science-Gossip."

Like all annual works of its kind, it is, as far as the strictly scientific reader is concerned, open to the charge of giving what is called in Scotland "pipers' news." But for educated though not professional readers it furnishes a survey of the discoveries and inventions of the past twelvemonths, alike fascinating and instructive. The author wanders on from one subject to another in an easy, natural, and conversational manner. In France it is not considered necessary to employ a heavy and ungainly style when writing on scientific topics.

The Vienna Exhibition naturally plays a prominent part, an entire chapter being devoted to the improved artillery there displayed, into which is introduced an account of the far-famed establishment of Krupp, at Essen. Another interesting chapter is occupied with the researches of M. Pasteur on fermentation, and the manufacture of beer, naturally leading to the consideration of atmospheric germs, and of the conditions and products of decomposition. The effects of alcohol, dietetically and medicinally, are next examined, and the dreadful effects of "absinthe," over and above those capable of being traced to the alcohol it contains, are fully expounded. It is surprising and disgraceful that this diabolical beverage is not totally proscribed by law in all civilised countries. It is painful to see that its sale is extending in England, no one—not even the temperance party—uttering a protest.

The sanitary influence of leaden water-pipes (a subject which the French engineers had much better have left to be dealt with by chemists) is discussed at some length.

We find an interesting account of certain human monstrosities which have lately attracted public attention, such as the "dog-man, Yeftichjew, and his son. It is remarkable that in the human subject an excessive development of hair is accompanied by a defective growth of the teeth.

The celebrated Guadeloupe skeleton has been assigned by the researches of M. Hamy to an age between the first appearance of the Caribs in the lesser Antilles, and the dawn of the historical epoch. When the Caribs first showed themselves in those islands is still, however, a very doubtful point.

It will be perceived that one subject follows upon another in this work in a somewhat promiscuous manner, without any regard to scientific method. To meet this difficulty we find at the end a "methodic table," in which the subject-matter is classified under the heads of astronomy, physics, mechanics, &c.

PROGRESS IN SCIENCE.

MINING.

About a month ago, Mr. Robert Hunt's annual volume of "Mineral Statistics" was issued from the Mining Record Office, being thus earlier by nearly a couple of months than the corresponding volume for the preceding year. This advance has been effected by the zeal of the Keeper of Mining Records, coupled with a readiness on the part of most of our mine-holders to respond to his solicitations. Indeed, so far as the collection of the colliery-statistics goes, matters stand precisely as they did last year; that is to say, the returns demanded by the Coal Mines' Regulation Act never come within sight of the Keeper of Mining Records, and, consequently, a special application has to be made to each coal-owner for the purpose of eliciting the needful information bearing upon the position of our coal-production. Even as regards the metalliferous mines, the compulsory returns, furnished in compliance with the Act, contain merely the quantity of ore raised; hence the percentage of metal, and the market value of the ore, have to be sought in other directions. From one source and another, however, Mr. Hunt manages to bring together a vast body of valuable information in his Statistical Annual, and this with the best possible guarantee that the information may be taken to strictly represent the true position of our mineral industries. The results of his labours during the past year may be epitomised in the following conspectus, which shows at a glance the amount and value of the mineral produce of the United Kingdom in 1873:—

	Tons.	Cwts.	Value.
Coal	127,016,747	0	£47,631,280
Iron ore	15,577,499	0	7,573,676
Copper ore	80,188	10	342,708
Tin ore	14,884	17	1,056,835
Lead ore	73,500	10	1,131,907
Zinc ore	15,969	0	61,166
Iron pyrites	58,924	3	35,485
Arsenic	5,448	17	22,854
Bismuth	1	4	68
Cobalt	0	6	12
Manganese	8,671	6	57,766
Ochre and Umber	6,368	8	5,410
Wolfram	49	19	526
Clays, fine and fire, and shale (estimated)	1,750,000	0	656,300
Salt	1,780,000	0	892,500
Barytes	10,269	11	7,993
Other earthy minerals (estimated)	—		3,000
Total value			£59,479,486

At a recent meeting of the Royal Geological Society of Cornwall, Dr. C. Le Neve Foster, Inspector of Metalliferous Mines for the West of England, read a paper on the Lode at Wheel Mary Ann, near Liskeard. This lode offers peculiarities of structure which deserve careful study by the mining geologist, for the sake of the light which they seem to throw upon the succession of changes that must have occurred in some of our mineral deposits. From Dr. Foster's observations underground, and on specimens taken from various parts of the vein, he has been enabled to deduce the following history of its formation.

fissure was first formed, accompanied probably by a shifting of the strata, so that a number of open spaces were left, and into some of these cavities fragments of the walls would eventually fall. These fragments were cemented into a breccia by the subsequent deposition of the cab, a sort of hornstone, which more or less completely filled up the fissure. At a later date the fissure was reopened, and lined with successive layers of quartz, galena, carbonate of iron, and calc-spar, together with fragments of the walls and of the prior-formed vein-stuff.

As it is of first importance to encourage habits of accurate observation among the young men engaged in our mining industries, we gladly call attention to a very creditable paper by Mr. A. K. Barnett, of Penzance, in which he offers some observations on the mineralogical and physical characters of the Elvan courses, the greenstones, and the sandstones of Cornwall, with remarks on their associated minerals. This paper, accompanied by a map of Cornwall, showing the Elvans and other intrusive rocks, is published in the last "Report of the Royal Cornwall Polytechnic Society." It is well known that the Elvan courses are intimately connected with the copper and tin lodes, on which they are generally believed to exert a beneficial influence, bunches of ore being frequently found at their intersection with the veins. A large number of the Elvans were examined by Mr. Barnett, who obtained a sufficiently fine collection of specimens to receive the Polytechnic Society's medal.

Whilst cross-sections of individual mines are frequently made, one does not often have an opportunity of seeing general transverse sections showing the connection of one mine with another, such as those recently prepared by Captain Maynard, of East Pool Mine, and described by him in the "Report of the Cornwall Polytechnic Society." By studying these sections, some of which are carried over several miles, and comprise a number of mines in their course, many facts are brought out which would probably be lost sight of in the study of sections which represent only individual mines.

In a paper on the "Geology of North West Lincolnshire," recently read before the Geological Society by the Rev. J. E. Cross, the position of the Lincolnshire iron ore, which of late years has been largely worked near Frodingham and Scunthorpe, was carefully examined, and its geological horizon definitely determined by palæontological and stratigraphical evidence. It appears that this iron ore occurs in the lower part of the Lower Lias, in the zone of *Ammonite semicostatus*. It is therefore much lower in the geological series than the celebrated Cleveland ironstone, which occurs in the Marlstone or Middle Lias. Possibly the ironstone worked at Caythorpe, near Grantham, may lie on the same geological horizon as the Frodingham ore.

A series of papers on the iron industries of this country is in course of contribution to the "Mining Journal," by Mr. Richard Meade, Assistant Keeper of Mining Records. The series commences with an article on the ironstones of Northamptonshire, and the history of iron smelting in that country. From the writer's position in the Mining Record Office, the statistical information in these articles will be in the highest degree trustworthy.

METALLURGY.

The present position of our metallurgical industries is well shown in the following general summary of the quantities and value of the several metals obtained from ores raised in Great Britain, during the year 1873, according to the statistics recently published by Mr. Robert Hunt:—

		Quantity.	Value.
Pig-Iron	Tons	6,566,451	£18,057,739
Tin	,,	9,972	1,329,766
Copper	,,	5,240	502,822
Lead	,,	54,235	1,263,375
Silver	Ounces	537,707	131,077
Zinc	Tons	4,471	120,099
Other metals (estimated)		—	5,000
		Total value	£21,409,878

Some beautiful bronzes from China and Japan, remarkable for their fine dark patina, contrasting strikingly with the silver work with which they were inlaid, have been examined by M. Henri Morin, of the Conservatoire des Arts et Métiers. His results have been laid before the Academy of Sciences of Paris, and are reproduced in the "Annales de Chimie et de Physique." M. Morin finds that all these bronzes contain lead, the amount in some cases rising to upwards of 20 per cent. As the proportion increases with the intensity of the patina, it is inferred that this patina is due to the actual composition of the alloy, and not to any external application. All the specimens contain zinc, and in one group the proportion of this metal rose to 6 per cent of the alloy. From some synthetic researches M. Morin is enabled to give the following recipe for the production of a bronze strongly resembling the finest productions of China and Japan:—Copper, 83; lead, 10; tin, 5; zinc, 2.

Nickel-plating has of late been very popular in this country, the metal being generally deposited, we believe, from a double sulphate of nickel and an alkali. Messrs. Baker and Unwin, of Sheffield, have recently patented an invention for the electro-deposition of nickel, their improved solution consisting of nickel oxide, and an alkali or mixture of alkalies, dissolved in tartaric acid. The following proportions are found convenient:—100 lbs. of nickel, and 67 of cream of tartar; or 100 lbs. of sulphate of nickel, 53 lbs. of tartaric acid, and 14 lbs. of caustic soda.

Under the name of *Galenite* M. J. David, of Paris, has patented a compound of lead, prepared from galena, to be used as a substitute for white-lead and red-lead. The powdered galena is roasted, at a low red heat, in open retorts, and the sulphide is thus oxidised into sulphate of lead: this product, having been ground in water, is dried, and introduced into commerce as galenite. The name appears to be very badly chosen, as some mineralogists are in the habit of applying it to the native sulphide, in order to bring the word "galena," into harmony with most other mineral names.

It is worth recording that Dr. Reichardt, of Jena, has been led to conclude that the presence of even a very small proportion of silicon in platinum may confer considerable brittleness upon this metal. A platinum vessel used in distilling oil of vitriol was found to be extremely crystalline and brittle, although new, and on analysis the following composition of the metal was obtained:—Platinum, 99·43; copper, 0·473; iron, 0·01; silicon, 0·03. The brittleness is referred not to the copper in the iron, but to the small proportion of silica.

MINERALOGY.

At Spring Creek, near the town of Beechworth, in Victoria, there are found —and, so far as we know, found there only—certain mineral structures known popularly as "water-stones," and scientifically as *Enhydros*. These peculiar bodies are irregular polyhedra, of chalcedony, having a hardness equal to that of topaz; in some cases dark brownish-yellow and nearly opaque, and in others colourless and transparent. They are generally hollow, and enclose a liquid with a movable bubble, like the air-bubble in a spirit-level. The enclosing shell is usually thin, and either smooth on the inside or encrusted with quartz. In the recently-published part of the "Transactions of the Royal Society of Victoria" will be found two papers descriptive of these enigmatical bodies. One of these papers, by Mr. J. E. Dunn, describes the geological occurrence of the Enhydros in granite and Silurian sandstone, at Spring Creek; whilst the other paper, by Mr. G. Foord, discusses the physical structure of the stones and the chemical nature of the enclosed liquid. This liquid appears to be a weak saline solution, consisting of water with a small proportion of the chlorides and sulphates of sodium, magnesium, and calcium; and it is believed that a soluble form of silica is also present.

In compliment to Prof. Dawson, Principal of McGill College, Montreal, the name *Dawsonite* has been bestowed upon a new mineral species, found in the joints of a trachytic dyke, near the western end of the College. This mineral has been studied by Dr. Harrington, the chemist and mineralogist to the

Geological Survey of Canada, who has recently described it in the "Canadian Naturalist." Dawsonite is a white, transparent, or translucent mineral, with a bladed structure, believed to crystallise in the monoclinic system. Two analyses revealed a remarkable composition, seeming to show that the mineral might be regarded as "a hydrous carbonate of alumina, lime, and soda; or perhaps a compound consisting of a hydrate of alumina combined with carbonates of lime and soda." If the existence of a native carbonate of alumina be admitted, the mineralogist will have no difficulty in understanding the composition of *Hovite*—a mineral described by Messrs. J. H. and G. Gladstone, in the "Philosophical Magazine" for 1862. It was suggested that Hovite might be a double carbonate of alumina and lime; but there has been some hesitation in accepting this suggestion, as chemists are not acquainted with a definite carbonate of alumina, or at least the existence of such a compound, as a laboratory product, seems doubtful.

A mineral, reputed to occur in rather large quantity near the town of Noumea, the capital of New Caledonia, has been examined by Prof. Liversidge, of Sydney, whose results have been published in the "Journal of the Chemical Society." The mineral is a soft, amorphous substance, of a fine apple-green colour, occurring with chrome iron-ore and steatite, in veins traversing serpentine rock. It appears, from Prof. Liversidge's analyses, to be a hydrous silicate of magnesium and nickel. We understand that the species is to be called *Noumeite*.

Some mineralogical notes have been communicated to Leonhard and Geinitz's "Neues Jahrbuch," by Dr. August Frenzel, who describes, among other minerals, a new species from Schneeberg, in Saxony, to be called *Miriquidite*—a name referring to the old Miriquidi forest, which formerly stretched over the whole Saxon Erzgebirge. The new mineral crystallises in the rhombohedral system, and contains oxide of lead, peroxide of iron, water, and arsenic and phosphoric acids; but a quantitative analysis has not yet been made,

Among some Russian minerals Frenzel has observed a specimen of native platinum in grains which were strongly magnetic. On analysis they were found to contain 76·97 per cent of platinum, and 10·97 of iron.

The extremely rare mineral to which Levy, many years ago, gave the name of *Roselite*, in honour of the late Gustav Rose, has been recently monographed by Prof. Schrauf, of Vienna. On a previous occasion we called attention, in these pages, to the recent discovery of this rare species at Schneeberg, in Saxony. The Daniel mine there has yielded some very fine examples, which have been thoroughly examined physically, crystallographically, and chemically, by Prof. Schrauf, whilst they have also been analysed by Dr. C. Winkler, of Freiberg.

Prof. Tschermak, of Vienna, has recently studied some of the remarkable meteoric masses found at Ovifak, in Greenland, and has published the results of his studies in the last part of his "Mineralogische Mittheilungen." This paper is preceded by a translation of Nauckhoff's Swedish memoir, descriptive of Nordenskjöld's discovery of the occurrence of native iron in a dyke of basalt. Tschermak's studies support the view that this iron is of meteoric origin.

In the last part of the "Mittheilungen" Mr. E. S. Dana, of New Haven, U.S., publishes the results of his morphological studies of the specimens of *atacamite*, or oxychloride of copper, from the Wallaroo mines, South Australia, now in the Imperial Cabinet at Vienna.

Microscopic mineralogy has come to be pursued almost as actively in this country as in Germany. Mr. Allport, of Birmingham, has recently recorded, in the "Geological Magazine," the occurrence of *Nosean* in the phonolite of the Wolff Rock—a rock which rises from the sea between the western extremity of Cornwall and the Scilly Isles. This is the first time that the mineral species nosean has been discovered in this country. Prof. Hull, of Dublin, has published a paper on the structure of the beautiful dark green porphyritic rock which occurs on Lambay Island, off the coast of Dublin. Nor should we forget a paper of considerable merit which has recently been communicated to the Geological Society by Mr. J. Clifton Ward, of the Geological Survey. In this memoir the author compares the microscopic and mineralogical composition of the modern lavas of Vesuvius with that of some of the old Welsh felstones, and of the eruptive rocks of the Cumberland Lake District. He finds that, as a rule, the Cumbrian rocks are intermediate in chemical and mineralogical composition between the *felstones* on the one hand and the *dolerites* on the other, whence he proposes to term them *felsi-dolerites*. Among foreign papers recently published we may refer to Prof. Möhl's "Mikromineralogische Mittheilungen," in which he describes some German basalts, and certain eruptive rocks from Java, Flores, and Arden; Baronowski's paper on the mineralogical and chemical composition of granite-porphyries; and Kalkowsky's memoir on the augitic felspar-porphyry near Leipzig. Finally, we may observe that a valuable monograph, entitled "Die Krystalliten," has recently been published as a posthumous work of Prof. Vogelsang, under the editorial care of his brother-in-law, Prof. Zirkel, of Leipzig.

In the admirable course of lectures on Crystallography now being delivered in London, by Prof. N. S. Maskelyne, an attempt is made to elucidate the Millerian system, which, to many English mineralogists, seems to require a greater amount of mathematical knowledge than the old and well-known system of Naumann. As we have so few writings upon Prof. Miller's system, except his own, the student may be glad to know that a capital outline of its principles has been published by the Smithsonian Institution in their last Report. The Essay to which we refer is translated from the German of Aristides Brenzina, by Prof. Egleston.

GEOLOGY.

Foreign Geology.—It is interesting to know that a Geological Survey is in progress in Japan. A preliminary report on the first season's work has been issued by the Chief Geologist, Mr. B. S. Lyman, an American Mining Engineer. It relates to the Island of Yesso. Among his assistants, Mr. Lyman speaks favourably of eleven Japanese, who are the first Asiatics to undertake the study and practice of geology. The formations determined consist of a variety of volcanic, Tertiary, crystalline, and other rocks; at present they have been for the most part classified according to certain systems of disturbance. The useful minerals and rocks noted are coal, limestone, ironsand, sulphur, gold, rock-tar, silver, lead, zinc, manganese, and copper.

Dr. Feistmantel has noticed the occurrence of workable coal-beds in Bohemia of Permian age. The lower part of the series contains the coal-seams, but both the upper and lower beds contain plants usually considered typically Carboniferous, *e.g.*, *Stigmaria ficoides*, and species of *Sigillaria*, *Pecopteris*, *Calamites*, &c. The Permian coal-beds are separated from the Carboniferous beds below, by shales with characteristic Permian animal remains. These Bohemian lower Permian beds may be paralleled, according to Dr. Feistmantel, with the beds containing *Archegosaurus* in the Saar and Rhine district, which he also considers as Dyas, and which lie upon the true Saarbrücken coal-measures.

The coal-bearing beds of Sweden, referred to in a recent report by Dr. Erdmann, are of Jurassic age, but the precise horizon to which they belong is not quite settled. Prof. Hébert considers them of the age of the Lias.

Among the fossils are *Amphidesma donaciforme*, *Avicula inæquivalvis*, *Pecopteris*, and Cycads. Prof. Torell notices the affinity of the flora to that of the Yorkshire Jurassic beds, and mentions the occurrence of *Solenites Murrayana*.

The relations between the Cretaceous and Tertiary strata in the United States have been the cause of considerable difference of opinion. The officers of the Geological Survey have lately take up the subject: Profs. Leidy and Cope, through the extinct Vertebrate fauna; Mr. Lesquereux, through the Fossil flora; and Mr. F. B. Meek, through the study of the Invertebrata.

The study of the fauna and flora of these different formations in different districts yields somewhat discrepant results; and there appears to be no alternative but to accept the conclusion that a Tertiary flora was contemporaneous with a Cretaceous fauna, establishing an uninterrupted succession of life across what is generally regarded as one of the greatest breaks in geologic time.

Palæontology.—Mr. L. C. Miall presented to the Geological Section of the British Association at Belfast, a Tabular View of the Classification of the Labyrinthodonta, which was divided into ten sections. Forty-two genera and 126 species are now known. Some of these animals, in their mode of life, appear to have been fish-like. Some resembled serpents, others crocodiles, whilst those of Kilkenny appear to have been salamanders.

Mr. Waterhouse Hawkins has recently expressed his opinion that the *Iguanodon* was a marsupial animal.

Remains of the Lemming have been found in lacustrine brick-earth at Salisbury, associated with bones of the Mammoth.

Prof. Rupert Jones records the occurrence of *Gyrogonites* (fossil seed-vessels of *Chara*) in the London clay of Islington. He also adds *Cythere plicata* to the known fauna of the London clay.

Lythology.—The study of rocks has of late become a popular one, and many important observations have been made.

A detailed examination of the Cumbrian ash-rocks has convinced Mr. J. Clifton Ward that, in many cases, most intense metamorphism had taken place, that the finer ashy material had been partially melted down, and a kind of streaky flow caused around the larger fragments. There was every transition from an ash-rock, in which a bedded or fragmentary structure was clearly visible, to an exceedingly close and flinty felstone-like rock, undistinguishable in hand specimens from a true contemporaneous trap. Such altered rocks were, however, quite distinct in microscopic structure from the undoubted lava-flows of the same district, and often distinct also from the Welsh felstones, (although some were almost identical (microscopically) with the highly altered ashes of Wales, and together with them resembled the felstone-lavas of the same country. This metamorphism among the Cumbrian rocks increases in amount as the great granite centres are approached; and it was believed by the author that it took place mainly at the commencement of the Old Red period, when the rocks in question must have been buried many thousands of feet deep beneath the Upper Silurian strata; and when probably the Eskdale granite was formed, perhaps partly by the extreme metamorphism of the volcanic series during upheaval and contortion. The author stated his belief that the Cumbrian volcanoes were mainly subaërial, since some 12,000 feet of ash and lava beds had been accumulated without any admixture of ordinary sedimentary material, except quite at the base, containing scarcely any conglomeratic beds, and being destitute of fossils. He believed also that one of the chief volcanic centres of the district had been the present site of Kenwick, the low craggy hill called Castle Head representing the denuded stamp or plug of an old volcano.

Prof. Hull has described the microscopic structure of a porphyry from the Island of Lambay, a few miles to the north of Dublin Bay. The order in which the different minerals seem to have been formed is as follows:—First, during consolidation, the crystals of orthoclase; next, the crystalline grains of magnetite; and lastly, the felsitic base itself. Then, after consolidation, chlorite, calcite, and pyrites.

Researches upon the thermal conductivity of certain rocks have been made by Prof. A. S. Herschel and Mr. G. A. Lebour. Among these, granite has been found to offer the least resistance to the passage of heat, and coal the greatest. Shale comes next below coal; but between these two and basalt there is a gap of considerable extent. Between basalt and granite come all the other rocks examined, including a number of limestones and sandstones of different varieties.

Physical Geology and Geography.—The Gippsland lakes, as described in a Colonial Report by Messrs. A. J. Skene and R. Brough Smyth, occupy extensive but shallow depressions in a great extent of level Tertiary country, and have been formed by elevation of the land. They are being gradually filled with mud and sediment; and every year, with the advance of settlement, the work of filling up will proceed more rapidly.

Professor Archibald Geikie has pointed out facts which lead him to conclude that the granite of the Isle of Arran is of Tertiary date.

The occurrence of erratics at higher levels than the rock masses from which they have been derived has been discussed by Mr. James Geikie. He points out that stones introduced into the body of a glacier, whether from above or below, tend to rise upwards in the ice, as the glacier flows on its way. This fact appears to him to solve the question; for a glacier travelling 50 or 100 miles may encounter many obstructions in the ground; and, if it surmount these, boulders may be extruded at its surface and stranded on the side of some rocky hill, many hundred feet or yards above the level from which they originally started.

The origin of the Cheddar Cliffs has been briefly treated of by Mr. H. B. Woodward, who advocates their formation by rain and rivers with both chemical and mechanical action.

Mr. John Horne, in a sketch of the geology of the Isle of Man, directs attention to the glacial beds. The Till (he remarks) is in all respects similar to that of Scotland, and is a product of land ice. There is abundant evidence of a strange intermingling of foreign rocks in it, which must have travelled from the coast of Cumberland, the south of Scotland, and the west coast of Ireland.

Sub-Wealden Exploration.—This great work progresses slowly and steadily. The Oxford clay, last reached, was still present at a depth of 1018 feet. Mr. Topley mentions that *Ammonites Jason* was met with at a depth of 990 feet. There does not appear to be the slightest break between the Kimeridge and Oxford clays; the Coral Rag and Calcareous grit being unrepresented, as is also the case near Aylesbury, and in Lincolnshire and Norfolk.

Mr. John Gunn has discussed, on several occasions, the probability of finding coal in the Eastern Counties, and he has recommended that an experimental boring be made at Hunstanton. It will be well, however, to await the results of the Sub-Wealden Exploration before attempting to prove the Palæozoic rocks elsewhere. We learn that at Sperenberg, about twenty-five English miles south of Berlin, a boring has been made by the Government engineers to the extraordinary depth of 4040 feet. This boring was made, after the first 283 feet, in salt-bearing strata; the great depth reached shows us what can be done with energy, and with funds!

Records of Geological Literature.—Mr. Whitaker has done great service to Geology by preparing lists of all papers on Geology, Mineralogy, and Palæontology, referring to certain districts. He has published those relating to London and Hampshire Basins, to Devonshire, Cambridgeshire, and Witshire. It is now proposed to publish, as a yearly volume, a record of all works (in the shape of short abstracts) that relate to Geology, whether British or Foreign. The first volume will be printed by the middle of 1875, and will contain records of papers, books, maps, &c., published during the year 1874.

PHYSICS.

LIGHT.—M. Craveri has devised a new helio-photometer. It consists of a box of hard wood, 280 m.m. long, 145 m.m. wide, and 200 high, forming a parallelopiped placed upon a pedestal in an open situation, where nothing impedes the direct action of the sun. The upper surface of the apparatus cannot preserve, during the twelve months of the year, a horizontal position, because when the sun sinks below the equator in winter its rays would fall too obliquely. It is therefore necessary at that season to follow approximately the movement of the sun. This result is obtained by gradually inclining the instrument towards the south from September to December, and gradually diminishing the inclination again till March, when it is replaced in a horizontal position. One of the principal sides of the parallelogram represents the door, fixed on hinges, and giving access to all the interior. At the side opposite the door is fixed a clock, the dial of which is seen through a circular aperture in the side. To this clock is adapted a toothed wheel, moved by the drum containing the spring. This wheel only performs one revolution in twenty-four hours. To its axle is fixed by a movable screw a large drum of brass, the circumference of which is 520 m.m., and the breadth 16 m.m. Upon the surface of this drum is fixed a slip of paper, as is done with the Morse telegraphs. A few seconds are sufficient for fixing or for removing this band. A slit in the box is so arranged that the sun's rays, shining through it, fall upon the band, even when the luminary is very near the visible horizon. The bands are prepared with chloride of silver by being steeped, first in a solution of common salt, and then, shortly before being used, in solution of nitrate of silver.

The students in the Physical Laboratory of Owens College having occasionally experienced some difficulty in obtaining the spectra of some salts with the ordinary Bunsen, through apparently a deficiency of pressure in the gas, it occurred to Mr. F. Kingdon that the amount of light, even at this deficient temperature, might be increased by multiplying the number of luminous points. This is accomplished by broadening out the flame of the Bunsen; that is, causing the gas to issue through a narrow slit instead of a round hole. So far, only a rough experiment has been made, the slit being about ⅞in. long and ⅛in. wide. The result, as expected, was a more brilliant spectrum.

MICROSCOPY.—In the Report of the Geological Survey of New Hampshire, some valuable information respecting the preparation of specimens of Diatomaceæ for examination and study by means of the microscope is contributed by Dr. A. M. Edwards, of Newark, New Jersey, U.S. Respecting the collection of Diatoms, some valuable hints are given. *Arachnoidiscus*, *Triceratium Wilksii*, and *Aulacodiscus Oregonensis*, may be looked upon for logs of wood which have been floating in the sea and imported from New Zealand or Vancouver's Island. So on logs from Mexico and Honduras may be found the curious *Terpsinæ musica*. The nets of fishermen from deep water may yield algæ bearing such forms as *Rhabdomena arcuatum* or *Adriaticum*, *Grammatophora serpentina* and *marina*, various *Synedras*, and other fine forms. On oyster shells may be found algæ bearing upon their fronds *Biddulphia regina*, *Bayleyii* or *aurita*. After a ship is unloaded, and as it floats higher in the water, its sides may be searched for treasures of the Diatom world. The sea-grass, *Zostera marina*, often bears upon its waving ribbons fine forms of Diatoms, and that used for stuffing chairs and imported from abroad will yield foreign species to the collector. The apparatus and materials used are those found in the possession of most well equipped microscopists. The chemicals required are nitric acid, sulphuric acid, hydrochloric acid, bichromate of potash, caustic potash, alcohol, distilled water, and washing soda.

Recent Gatherings.—Sand to be removed by shaking in clean water and pouring off before the diatoms, which are lighter than the sand, settle. After the diatoms have settled as much as possible of the water is to be poured off from the test-tube containing them. They are now covered with nitric acid and allowed to stand a few minutes. Usually some chemical action takes place, and it will be well to wait until it subsides. The tube or beaker is then held over the lamp and carefully heated until the reaction of the acid upon the organic matter of the diatoms ceases. Then, while the liquid is still hot, a few small fragments of bichromate of potash should be dropped in. The organic matter is more thoroughly destroyed in this way than when the acid is used alone. The acid and diatoms should then be poured into a capacious beaker of clean water, washing the test-tube out with a little water and adding this to the other. After the diatoms have settled, the supernatant fluid is carefully poured off, and a fresh supply added; this must be repeated until all the acid and coloured chromium compound has been removed. When this point is arrived at can only be ascertained from experience.

Muds will have to be treated in a somewhat different manner from recent gatherings. If the mud is dry it must be broken down by boiling for a few minutes in a solution of caustic potash, the strength of which must be apportioned to the particular specimen under treatment. After it has been broken down into a soft mud, all the potash is thoroughly washed away by means of clean water, and replaced by nitric acid as in the case of recent gatherings. This is boiled and a little bichromate of potash added as before, and the whole washed. Diatoms occurring in mud are very seldom sufficiently cleaned by this process, so that it it has to be supplemented by another. The sediment is washed into an evaporating dish and allowed to settle, and as much of the water poured off as possible. Then sulphuric sufficient to cover the deposit is poured in and the vessel gradually and carefully heated. As soon as the liquid shows signs of boiling, bichromate of potash is added a very little at a time, until the green colour first formed begins to assume a yellowish tint when no more is dropped in; but a few drops of hydrochloric acid are permitted to fall in, and the liquid is allowed to cool. As soon as the liquid has cooled a little, water should be added cautiously, as great heat will be generated and there will be danger of boiling over. It is then to be poured into a large beaker of water and washed as before. If it be found that the precipitate is not quite white, it will be necessary to boil it again in sulphuric acid, with bichromate of potash and hydrochloric acid until it is quite clean. If upon examination under the microscope much flocculent matter is present besides the diatoms and sand, this can be removed by boiling for a few seconds in a weak solution of caustic potash and washing quickly with plenty of clean water.

Guanos.—The preparation of these substances is rather tedious, difficult, and dirty. The ammoniacal guanos are those which contain most diatoms, that from the islands upon the coast of Peru may be taken as a typical specimen. As it comes into commerce, it is a moist powder of a light iron-rust colour, smelling strongly of ammonia and having scattered through its mass lumps of ammoniacal salts of a more or less solid consistency. The guano should be thinly spread out on a stiff sheet of paper and exposed to the air at a moderate heat for a few days, until the moisture and most of the ammonia have evaporated, and less acid will be required to clean the guano. It will now have become much lighter in colour, and crumble to a dry powder. A tin pan is now about half filled with a solution of common washing soda in clean filtered water and placed over some source of heat, as on a stove. The strength of the solution is not a matter of any great moment and must vary with the guano manipulated. As soon as it begins to boil the guano is dropped in, a little at a time, while the liquid is stirred with a glass rod or stick of wood. Considerable effervescence takes place, ammonia being given off; therefore it must be kept continually stirred, and care exercised to prevent its boiling over. It is then poured into a plentiful supply of clean water and washed several times, care being taken to permit all the diatoms to settle. As soon as the wash-water is only slightly coloured, the guano is transferred to a suitable evaporating dish and covered with nitric acid and boiled. While boiling a few crystals of bichromate of potash are added, and the material treated as in the case of muds. Phosphatic guanos, are somewhat more difficult to treat. They are generally drier than the ammoniacal kind, and must be boiled in a large quantity of hydrochloric acid as many as three times, and the acid must be poured off while still hot. Afterwards, nitric acid and sulphuric acid and bichromate of potash must be employed as in former cases.

Lacustrine Sedimentary Deposits.—For the most part these are pulverulent, and easy to clean. Some, as found in nature, are so pure that they require no cleaning except washing in clean water. Burning on a plate of platinum will often serve to clean some specimens; but it will, in general, be found best to boil in nitric acid with a little bichromate of potash, and subsequently in sulphuric acid and bichromate of potash with the after addition of hydrochloric acid. Occasionally an amount of flocculent matter will be left, which can be removed by very careful heating (not boiling), in a weak solution of caustic potash, and immediately pouring into a large quantity of clean water and thoroughly washing.

Marine Fossil and Sub-Plutonic Deposits, being stony and possessed of very much the same physical characters, are manipulated in the same manner. A small lump of the deposit is placed in a test-tube, and covered with a strong solution of caustic potash. It is then boiled for a few minutes, and usually it immediately begins to break up and fall down in the shape of a soft mud-like material. At once the liquid, with the suspended fine powder, is poured off into a large quantity of clean hot water, and if the whole of the lump has not broken down into a powder, what remains has a little water poured over it in the test-tube, and is again boiled. It will be found that a little more will now crumble off. This is to be added to the rest in the large vessel, and if the lump has not now broken down, it is again boiled in the alkaline solution and in water alternately, until it has all been disintegrated. It is then all permitted to settle for at least three hours, when it is thoroughly washed and boiled in hydrochloric acid for about half-an-hour. There is then added an equal amount of nitric acid, and the boiling continued for a short time. It is then washed and heated in sulphuric acid with the addition of bichromate of potash and hydrochloric acid.

The following preservative fluid is recommended for mounting recent specimens. To one ounce of distilled water add two or three drops of wood creosote and a sufficient quantity of alcohol to make the creosote soluble in the water; this will about equal double the quantity of the creosote. The methods of mounting recommended by Dr. Edwards are those well known to all skilled microscopists.

In a paper on blue and violet stainings for vegetable tissues, Dr. C. Johnson, of Baltimore, gives the following formulæ for a useful stain for this purpose:—Ordinary logwood extract is finely pulverised in a mortar, and about three times its bulk of alum (in powder) added; the two ingredients are well rubbed up together, and mixed with a small quantity of distilled water. The complete admixture of the alum and hæmatoxylin is necessary, and this will require fifteen or twenty minutes vigorous trituration. More water may now be poured on, and the solution, after filtration, should present a clear, somewhat dark violet colour. If a dirty red be obtained more alum must be incorporated and the mixture again filtered. After standing several days add 75 per cent alcohol in the proportion of two drachms to one ounce of the fluid. Should a scum form on the surface of the liquid at any time, a few drops of alcohol and careful filtering will be all that is required. This fluid colours very rapidly, requiring but a few minutes, whereas, if a slower tinting be desired, the fluid may be diluted with a mixture of one part alcohol and three parts water. The sections to be stained having been kept in alcohol, place them in a weak dilution of the fluid and watching the result, transfer the morsel to dilute alcohol for washing, and afterwards to strong alcohol in anticipation of mounting. If it be intended to display the general structure let the tint be decided; but if it be wished to give prominence to the vessels a faint blue only should suggest the other parts. In treating thin leaves or fresh green sections, the colour must first be removed or else staining will be of little service. The bleaching is to be accomplished through the agency of Labarraques's solution of chlorinated soda, in which the objects should be macerated until perfectly colourless and transparent. They should then be immediately transferred to distilled water for an hour or two, and then to a 3 per cent solution of oxalic acid in 50 per cent alcohol, which neutralises the soda and prepares the tissue to take the dye, particularly if aniline blue is employed. The oil of cloves process is to be employed in the final mounting in balsam. The aniline solution preferred by Dr. Johnston, is "Bower's Blue Ink" slightly acidulated with oxalic acid, Dale's soluble blue No. 3 (Robert Dale and Co., Hulme, Manchester) is also recommended. Staining with aniline blue is somewhat more uncertain than that with the hæmatoxylin solution, and the colour of the latter is preferable, especially for observations by artificial light.

The antennæ of the male gnat, *Culex pipio*, have long been favourite objects with microscopists, and when viewed under the binocular and suitably illuminated are scarcely surpassed by any low power object. Some experiments on an allied species, *Culex musquito*, by Alfred M. Mayer, go very far to prove that the beautiful whorls of fibres with which the antennæ are armed serve the purpose of very delicate auditory organs. Observations under the microscope upon living mosquitos show that the delicate setæ respond to the vibrations of tuning-forks, some vibrating to certain notes while the others remain at rest. Further experiments would seem to determine the function of this singular auditory apparatus, namely, to guide the male in the direction of the peculiar humming made by the female. The paper is too long for the quotation in full.

Mr. J. K. Jackson communicates to "Science Gossip" a process for fixing diatoms in devices. The operator is supposed to start with a stock of perfectly clean material, and that a "dip" has been evaporated on a slide. The tool used is a hair from a cow's neck, mounted in a light wooden handle.* The diatom selected is picked with the hair under a 1½-inch power and placed on a prepared thin cover, made as follows:—Take filtered gum tragacanth, and mix five or six drops with one ounce of distilled water. The covers are then cleaned and placed on a rack formed of six pieces of wood, six inches long, a quarter of an inch broad, and one-eighth of an inch thick, made into a "rack" by having pieces of copper wire run through the lot near to each end, so that the bars of the rack slid on the wires may be altered to suit different sizes of covers. Each cover has then a minute drop of the gum placed on its centre with a fine pipette, special precautions being taken to prevent the introduction of dirt. The loaded rack is then transferred to the hot plate and the gum dried as speedily as possible. The covers when dry are stored for use under a well closed glass shade. When required for use, one of the covers is placed on a wooden slide having a hole suitable to the size of the thin glass employed. On this cover the diatoms selected are placed with the cow's hair. When sufficient frustules have been collected to form the device, they are "pushed, coaxed, or driven," into the required form, under an inch and a half objective. When this has been accomplished, after the exercise of much trouble, patience, and dexterity, the cover with its device must be brought close to (just within) the mouth, and breathed upon—one slow, long breath. The cover must then be dried upon a hot plate and turned over on to a drop of balsam and benzol, or damar, in the centre of a slide, and if the glaze on the cover be of the proper thickness, the balsam may be boiled without displacing a single diatom. The writer adds the following hints:—(1). Never hope for one drop of clean water unless you distil it yourself. (2). Place your diatoms "on their backs" in the gum, else they will retain air, which nothing can expel. (3). "Mind your eye," or rather your eyes, as the process is a very trying one to the sight.

Mr. G. J. Burch has communicated to the Quekett Microscopical Club his method of making extremely thin glass covers. Take a piece of glass tube about a quarter of an inch bore, seal up the end with the blowpipe, and continue the heat until the glass is so soft that it will fall out of shape, unless you keep turning it round; remove it from the flame, and blow into it with all your strength. It will be seen to swell, at first slowly and then suddenly, to a large bubble of very thin glass. Supposing the tube to have been sealed up with as little glass as possible, it may be blown out to about four inches diameter. When cold break it up and cut the pieces to shape with a writing diamond. The glass is of course curved, but it may be flattened by being placed on a perfectly flat piece of platinum foil, and depressed for a moment into the Bunsen flame; as soon as it is red hot, it will sink down to the flat foil. This has also the effect of annealing it. A piece of this glass was found upon measurement with the micrometer to be only 0·0004 of an inch.

HEAT.—Dr. G. Krebs, in a paper on the determination of the freezing-point for delicate thermometers, says:—Schultz, in his treatise on the freezing-point of the water of gaseous solutions and the regelation of ice, shows that the freezing-point of water is lowered by dissolving gases, the change being nearly proportional to the amount of gas dissolved. That water holding solids in solution freezes at a lower point is well known. Thomson and Clausius have shown from the principles of mechanical theory of heat that the freezing-point of water falls 0·007° C. for every additional atmosphere of pressure. To determine the true freezing-point, take a glass tube closed at one end, 20 centimetres long and 2 wide, fill it almost full with sulphuric acid, and heat. Then pour out the acid, and rinse repeatedly with pure distilled water. The tube is then two-thirds filled with distilled water, which has been boiled for some time in a clean beaker, and a small quantity of filtered oil of turpentine (about 1 centimetre in depth) is poured upon the water. The tube is then carefully heated in the oil-bath, without allowing the temperature to rise to the boiling-point lest an explosion should ensue. The object of the heating is to remove any air bubbles which may adhere to the side of the glass or may remain between the turpentine and the water. When the water has been thus exposed for a considerable time to a temperature very near to the boiling-point, the tube is taken out of the oil-bath, cooled in cold water, and then placed in a freezing mixture (water and nitrate of ammonia). After a few minutes the water is cold, and in most cases a portion of it freezes at once if a thermometer is inserted, and moved up and down. If this does not take place the tube must be returned to the freezing mixture, and cooled more strongly. The thermometer may be previously placed in an empty test-tube, which is then plunged in the freezing mixture. It is very important that the thermometer should be cooled down close to the freezing-point before being introduced into the water. The best thermometers when tested in this manner show a freezing-point too high by about 0·1° C.

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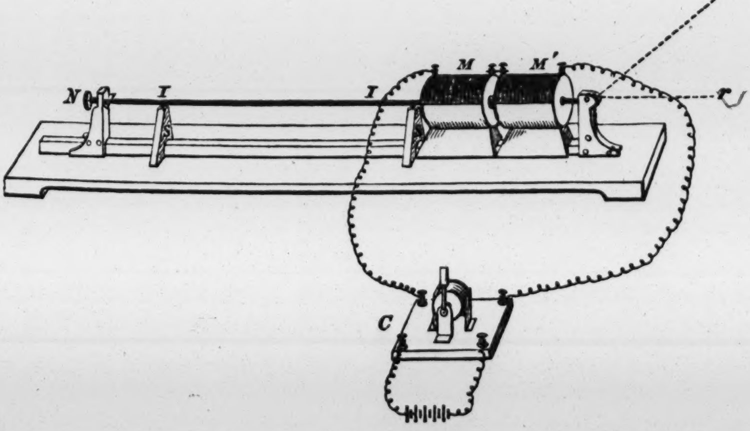
* A fine bristle split at the end is preferred by some authorities.

ELECTRICITY.—In a paper read by Prof. W. F. Barrett, F.R.S.E., M.R.I.A., on the "Molecular Changes that accompany the Magnetisation of Iron, Nickel, and Cobalt," at the British Association Meeting, at Bradford, it was shown that certain molecular phenomena known to attend the magnetisation of iron were found to accompany the magnetisation of nickel and cobalt. Notably this was the case with the peculiar sound emitted on magnetising and demagnetising these metals; with cobalt the note was clear and metallic, and louder than in the case of iron. The physical as well as the chemical properties of the three magnetic metals were, in every case, proved to be so closely similar that it was reasonable to expect that any cause producing a molecular change in the one metal would produce a similar change in the other. A series of preliminary experiments established the fact that a change in the dimensions of nickel and cobalt occurred on their magnetisation by an electric current, corresponding to the elongation and retraction of iron investigated by Dr. Joule. To pursue this enquiry further a committee was appointed, consisting of Prof. Balfour Stewart, and subsequently Prof. Clerk Maxwell, in conjunction with the author, and the results were embodied in a report read before Section A of the British Association at Belfast; after the trial of various arrangements an instrument was devised, and has been constructed by Messrs. Yeates, of Dublin and London, by which it is hoped precise determinations may shortly be made

FIG. 1.



(Figs. 1 and 2). Associated with these molecular changes are others relating to the heating and cooling of wires of the magnetic metals. Mr. Gore discovered that an iron wire, when raised to a white heat, underwent an anomalous expansion at a certain point during its cooling. On repeating Mr. Gore's experiments, the author found a similar anomalous deportment during the *heating* of iron wire,—the wire momentarily contracting when the temperature of a dull red heat was reached, and, as far as the eye could judge, this was also the temperature at which the elongation occurred in cooling (Figs. 3 and 4).

FIG. 2.

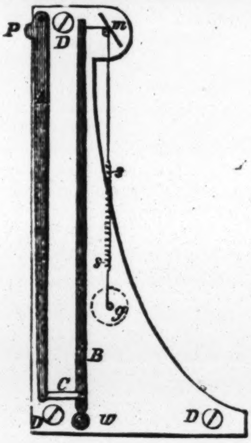
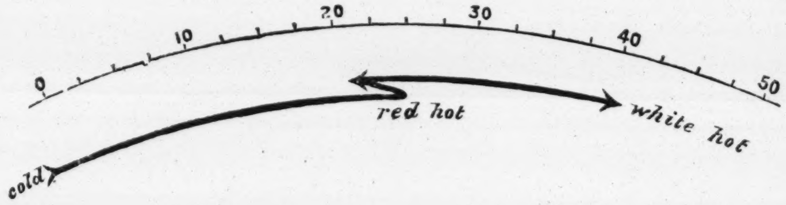


FIG 3.



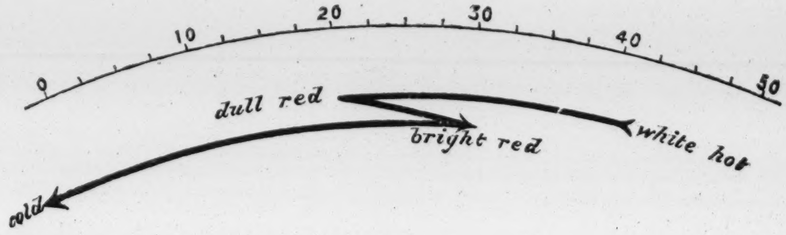
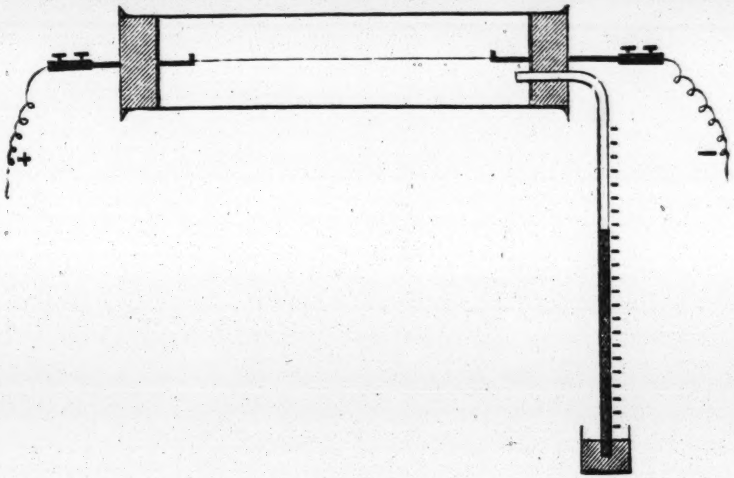


FIG. 4.

Examining the wire during the experiment, in a darkened room, another remarkable phenomenon was revealed, viz., that at the critical point during the *cooling* of the wire a sudden glow diffused itself over the wire, whereby it was raised from a dull to a bright red heat. During the heating of the wire—whether by an electric current or by a row of gas flames—a momentary cessation of heating occurred at the critical point. Enclosing the wire in an air thermometer, these effects were made more evident,—the expansion of the air during the heating of the wire ceasing for a moment, when a dull red heat was attained; and on cooling, the after-glow caused a momentary and violent depression of the liquid index (Fig. 5). A crepitation in the wire was heard at the moment this change took place. Moreover, the critical temperature was approximately that at which iron lost its magnetic character upon heating or regained it on cooling. Further Prof. Tait has shown that at this temperature the thermo-electric condition of iron changes, and that at a lower temperature nickel undergoes a similar change. Hence it is most probable that nickel and cobalt will be found subject to analogous molecular changes at the temperature wherein their transition from the magnetic state takes place,—nickel at a lower temperature than iron, and cobalt at a higher. Experiments have also been made to exclude the effect of oxidation during the heating of the wires. Iron and steel wires have been enclosed in atmospheres of hydrogen, nitrogen, and carbonic acid gas, and in each case similar effects are produced to those already described. In carbonic acid the gas is decomposed around the heated wire, and brilliant scales, apparently of graphite, are deposited on the iron. The foregoing remarks the author begged to be regarded as merely fragmentary observations, preliminary to a more detailed investigation which he hoped shortly to undertake. After Prof. Barrett's paper had been read the following discussion took place.

FIG. 5.



Prof. CLERK MAXWELL said—In theoretical investigations an assumption is often made that if you make a slight change in the circumstances a slight change will be produced in the result; but this is not always the case in Nature. It seems that in the cooling of iron wire, described by Mr. Barrett, something goes off at a certain moment—something tumbles over at the moment of the kick. Other things tumbled over too,—traps for catching mice, for instance,—and the parts might not have the power of getting up again. If a row of bricks were placed on end, and the first one knocked down, it would knock down the next, and so the whole row would tumble down. When I was a boy we used to call this "Sending Jack for mustard." This mode of the transference of motion was not the same thing as wave motion, because in a wave the particles swing back, but the bricks have to get up again how they can, and won't return to their former position automatically. So in Prof. Barrett's experiment, a critical point is reached where a break down occurs among the molecules. In the process of cooling iron wire something happens which makes a noise, makes the wire lengthen, and make it glow again. A slight change in the circumstances has made a great change in the phenomena. Seeing Mr. Herbert Spencer present reminds me he has written that something of the kind may take place among the nerves, though I do not agree with the assumption he has made.

Prof. Guthrie—Having had the opportunity of seeing Mr. Barrett's experiments, I think Mr. Barrett remarked the re-heating passed along the wire in a definite direction; the glow did not appear immediately all over, but travelled along the wire.

Prof. G. C. Foster—The wire is not likely to rise equally in temperature, or to fall equally, through the whole wire. The ends are fastened to masses which tend to cool them quicker than the central parts of the wire. Is there evidence of anything more than this in the phenomenon described?

Prof. Barrett—It is the fact, as Prof. Guthrie has mentioned, that the "after-glow"—as Prof. Tait has called it—does not appear simultaneously throughout the wire. A wave of heat seems to travel along the wire, and the sudden rise of temperature and measured progress of this wave are very beautiful to observe. I do not think the existence of this wave is due—at any rate not wholly due—to the unequal distribution of heat caused by the masses of metal to which the wire is attached. For, in reply to Professor Foster's question, I may remark that if an iron wire, such as that tying down the cork of a soda-water bottle, be coiled round a pencil, and the helix of wire thus formed heated in some dark corner in a Bunsen gas flame, on the withdrawal of the wire from the flame the after-glow will be readily seen, generally traversing the wire in the manner already described. I am inclined to think the existence of this wave may be due either to an inequality in the diameter of the wire, to a want of homogeneity in its structure, or to the accidental passage of air-currents; for the progress of this wave is sometimes in one direction and sometimes the opposite.

Mr. Herbert Spencer—Is it the fact that the wire having once undergone this transformation, when it passes to a lower temperature, and is again heated, it will undergo a similar change?

Prof. Barrett—This is the case. The after-glow can be made to appear a dozen or more times upon the same wire. But the phenomenon becomes fainter each time. The gradual extinction of the after-glow which I have thus obtained seems to depend very much on the degree of tension to which the wire has been subjected during the heating and cooling; but this is a point I have reserved for future experiments, and cannot therefore speak positively upon it now.

Prof. Everett—Is there a want of symmetry between the sudden change which occurs during the heating and that which occurs during the cooling? Would Prof. Barrett be good enough to draw the temperature curves for both?

Prof. Barrett—I am much obliged to Prof. Everett for his suggestion. The following curve will approximately represent the progressive temperatures of the iron wire during its heating: where A B, in Fig. 6, represents the time the wire is exposed to the source of heat, and A C the increment of temperature, judged by the eye or an air thermometer. A pause in heating, *d d'*,

Fig. 6.

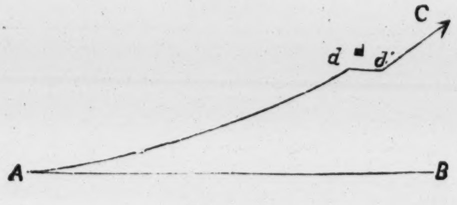
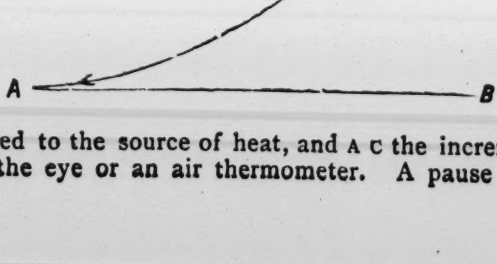


Fig. 7.



occurs at a dull red heat. On the other hand, the cooling of the wire may be represented as in Fig. 7. Here there are two points, *d d'*, at different intervals of time in cooling, where, nevertheless, the temperature of the wire is the same. The curves, therefore, are not symmetrical. Of course the continued accession of heat in Fig. 6 would mask any small fall in temperature if such occurred. In both cases the anomalous temperature is seen only as the result of a differential action.

After a remark by Professor Clerk Maxwell on the analogy of these phenomena with Mr. Spencer's statement on the propagation of nerve force already referred to,—

Mr HERBERT SPENCER replied—I rather think that Mr. Barrett's experiments confirm my hypothesis. When the nerve impulse has been expended, I infer that the nerves are reinforced from the neighbouring tissues. They fall in temperature, and instantly absorb heat from adjacent tissues. As a verification of this inference, I may mention we have evidence that the velocity of nervous transmission is variable according to the temperature of the body—the current being swifter in summer than in winter, which corresponds with the fact that the "personal equation" is a variable element in different individuals, and may be presumed to vary in consequence of their slight difference of temperature.

Professor MAXWELL—I attribute to Mr. Spencer the view that the nerve recovers its power of acting by absorbing heat. The people who read such a statement might attribute to him the notion that the nerve acts as a heat-engine. It may be that when the nerve is raised to a higher temperature, some chemical action may be able to take place which, though it is a lowering of the available energy of the system on the whole, may make it more available for giving another impulse—another wave of nerve force—but at the same time, after all is done, the nerve is worse off than before, so that it has to receive from the blood something to bring it up to its former state. The two sides of the interpretation are these: We all admit that nerves won't go on without food, but it may be possible that some action, depending upon the absorption of heat from the surrounding tissues, may make the nerve more instantaneously available. But those who believe in thermo-dynamics, and the dissipation of energy, cannot admit that any purely material system can convert heat into work when the system and its whole environment are, at the commencement of the operation, at the same temperature. There is a statement in Sir W. Grove's address on continuity, in which he mentions that Berthelot had discovered that a certain salt could undergo chemical change in which its energy was increased by absorption of heat from the surrounding medium, at a temperature no higher than its own. That statement has not been attacked; but, though it supports Mr. Spencer's view, it cannot be understood literally by anyone who believes in Carnot's law, which expresses under what conditions heat can do work in passing from one thing to another.

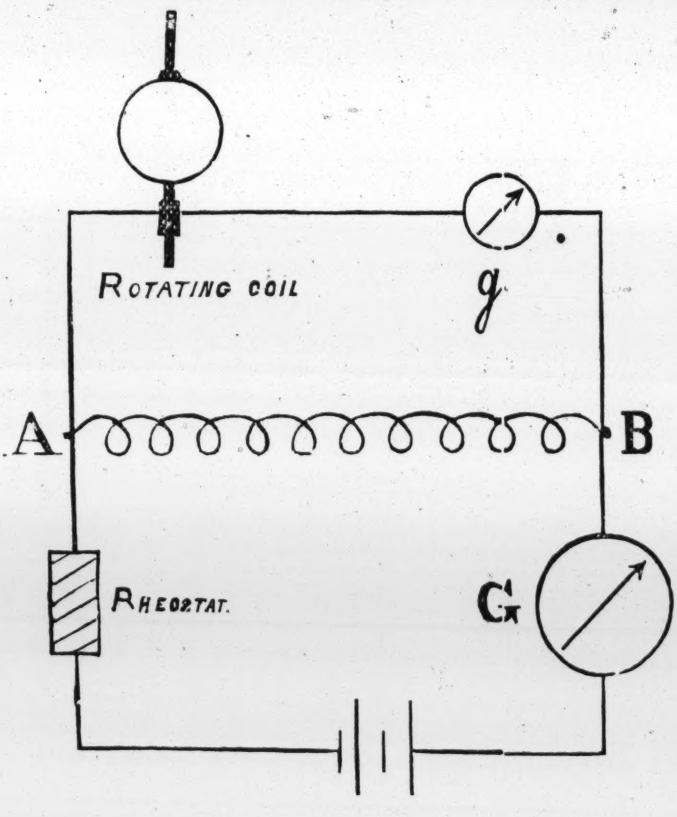
Mr. HERBERT SPENCER—I by no means assume that there is any genesis of force made possible in a nerve by any such absorption of heat. Although not very familiar with thermo-dynamics, I am sufficiently so to be aware that there is no possibility of such an evolution of force in the nerve except at the expense of the body at large. I am merely endeavouring to show that we have in the heat of the tissues surrounding the nerve a reserve of force ever present, which may be transformed into the force that traverses a nerve simply by the instrumentality of the change in the isomeric forms of the molecules of nerve; which change is a change of a kind permitting them, each time they absorb heat, to assume a less stable form, and therefore again to fall into the more stable form. It is a perfectly reasonable hypothesis that a nerve may be composed of material which, like all the other forms of protein, admits of extremely easy change from one isomeric state to another. If it is supposed that by the absorption of a small amount of heat, the molecules of the nerve assume such a relation, that by a slight disturbance they will again resume their more stable state, and send a cumulative wave of disturbance—like Professor Maxwell's line of bricks:—I say it is a feasible assumption that when they have done that, they have lost heat to the extent that they have given out that wave of motion, and are in a condition to absorb heat from the tissues. That the ability of the nerve to perform its function depends on absorption of heat from the surrounding tissues is a supposition confirmed by the fact that, if you reduce the temperature greatly, the nerve ceases to act.

Professor CLERK MAXWELL—No doubt there is plenty of power in the heat of the body to renovate a nerve. But as heat can do work only by passing from a hotter body to a colder, "all the king's horses and all the king's men" could not renovate the nerve by the aid of heat alone.

At the late British Association Meeting at Belfast an important communication "On the Absolute Electro-Magnetic Units of Resistance and Electro-Motive Force, with Suggestions for their Re-determination," was made to Section A by Prof. G. Carey Foster. The method consists in determining the ratio of the electromotive force to the strength of the current produced by it in a given conductor; and then, since—

$$\frac{E}{C} = R,$$

the resistance of the conductor is determined. For this purpose a large coil of covered copper wire, like a hoop placed vertically, is made to rotate about a vertical axis, so as to have a certain electromotive force E generated in it by the horizontal component of the earth's magnetic force. During each half-revolution beginning and ending with the plane of the coil at right angles to the magnetic meridian, the mean value of E is—



$$\frac{2aH}{t},$$

where a is the effective area of the coil, t its time of revolution, and H the earth's horizontal intensity; but during successive half-revolutions the sign of

E is alternately positive and negative. The ends of the wire of the coil are connected with a commutator on its axis (as in an ordinary Delezenne's circle), which causes the current in all external portions of the circuit to flow in only one direction. This being arranged, all that would be wanted, in order to know the resistance of the wire of the coil, would be to measure the strength of this current, and calculate the electromotive force by observing the speed of rotation. But it is plain that the resistance so calculated would include the resistance of the commutator, which is variable and wholly irregular, so some modification is necessary which shall entirely eliminate this source of error. Prof. Foster manages this by applying Poggendorff's method of measuring E.M.F.—that is, by stopping all current in the coil with a branch of an auxiliary stronger current. A constant battery (shown in the diagram) has its circuit completed through a Siemens unit, a standard coil, or other conveniently-mounted resistance, A B, which it is desirable to know in absolute measure. A certain difference of potential exists between the ends of the wire A B, and this can readily be altered by changing the resistance of other parts of the circuit till it is precisely equal to the electromotive force generated in the coil when revolving at some constant rate. There is a delicate Thomson's galvanometer, *g*, in the coil circuit, which shows when the two differences of potential are equal by the absence of all current through it; and when this point has been attained, the battery circuit is totally unaffected by its connection with the coil. The strength of the current in A B is now to be very carefully measured in absolute measure by an accurate absolute tangent-galvanometer, G; this current is produced by an electromotive force E (which we have arranged to be equal to the difference of potential between the ends A and B) acting against the resistance R of the wire A B; but the electromotive force of the coil is also E, and therefore it could produce exactly the same strength of current against the same resistance R. Thus the strength of the current which the calculated electromotive force E of the coil could produce against the required resistance R is measured when there is no current at all circulating in the coil. The absolute resistance of the wire A B is now known, for—

$$R = \frac{E}{C} = \frac{\frac{2aH}{t}}{k\,H\tan\delta} = \frac{2a}{k\,t\tan\delta};$$

k is the constant depending on the particular tangent-galvanometer, and has of course been previously determined. The horizontal intensity of the earth is eliminated from the result, as it appears both in E and C; and this is important, since it is a thing very difficult to determine accurately, and is liable to local disturbances. The advantages of the whole method which are peculiar to itself are—first, that the wire whose resistance is to be measured may be of the most convenient form and material for accuracy and constancy, and any wire whatever may be measured just as easily as any other; second, that the strength of the current is not measured by some arrangement inside the revolving coil, but by an independent accurate tangent-galvanometer, whose sensitiveness may be so adjusted that the needle may be deflected about 45°; and, further, that by applying Bosscha's modification of Poggendorff's method (that is, after measuring as before, add a certain resistance to the wire A B, and then compensate it by a known addition to the external circuit, and so on) the E.M.F. of any cell may be compared directly with that of the coil, and so found in absolute measure. In the discussion which followed, Prof. Guthrie and the President (Prof. Jellett) both doubted whether the irregularities in the resistance of the commutator were wholly got rid of by the method. Prof. Foster explained that, as when the measurement is to be made there is no current in the coil, a change of resistance can have no effect. If the circuit were properly balanced, the needle of the galvanoscope would remain at rest, whether the resistance of the commutator were 0 or ∞; the only thing is that if the resistance of the commutator were infinite, the coil would be disconnected, and there would be no experiment; so the effect of an increase of resistance at the commutator is to diminish somewhat the *sensitiveness* of the method, but it has no effect on anything else. Prof. Clerk Maxwell said that the method seemed capable of furnishing very good results, and was well worth putting into operation. He said, also, that the change of resistance at the commutator was entirely eliminated, but that the change of E.M.F., due to heat at the contacts, was not; however, Prof. Lorenz had used a revolving commutator and had not been much troubled by this effect, and he got rid of what little there was by reversing the current in different experiments. The commutator must be accurately made, so as to cut off the current a definite proportion of each revolution. Prof. Wiedemann said it would be important to measure the area of the revolving coil accurately, and this, he thought, might be found the most difficult part of the experiments. Prof. Maxwell then explained a contrivance he had devised for ascertaining the dimensions of large coils, by letting a wheel (on whose axle a string could wind itself) roll on the wire as it was wound on, and afterwards running this wheel along a scale till the string was unwound. The length of the wire and number of turns is thus known, and from these the effective area of the coil is easily found. Prof. Maxwell further suggested that the commutator should only make contact for a very short time in each revolution, as this would do away with any self-induction (or extra currents) which might take place if contact were made long enough for the current to vary much in intensity.

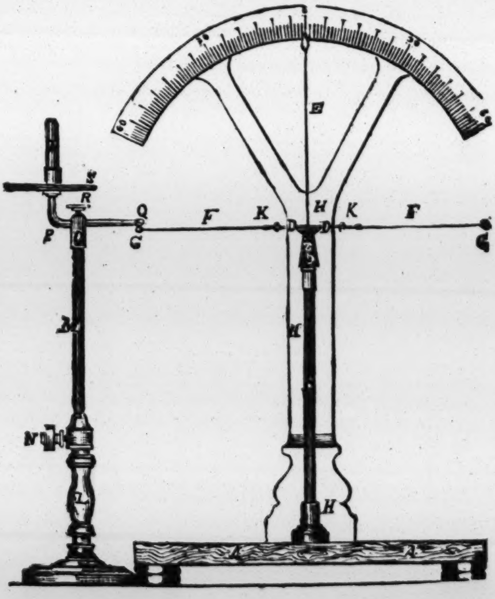
Mr. S. M. Yeates, the excellent philosophical instrument maker, in Dublin, has invented a most important modification of the step-by-step telegraph. In all alphabetical telegraphs hitherto made it is essential that the operator should always move the handle round in one forward direction, and therefore, if a letter be required which precedes the one last indicated, it is necessary to carry the pointer all the way round the dial in order to indicate the letter required; if, for instance, the word "day" be transmitted, the operator moves the index from zero to D, passing over A, B, and C; having thus passed A, it becomes necessary to go all round the dial to arrive at A, and having passed Y must again go round the whole alphabet before the word is completed. As each letter passed by the transmitting instrument sends a current which actuates the receiving instrument, and makes its index perform the same motion, it follows that, in transmitting this little word "day," there are no less than 49 currents sent along the line, and, as any one of such currents may miss, there are 49 chances of the instrument "tripping," as it is called. In Mr. Yeates's new instrument both the transmitting and receiving instruments work backwards or forward indifferently, and therefore—in the case supposed of the word "day"—the operator, having moved the index to D, has only to move it back to A, and then back to Y, thus transmitting the word with only eleven contacts, instead of forty-nine as in the other cases. The great advantage gained by this will at once be seen:—First, it greatly increases the speed of the instrument; and secondly, it greatly lessens the chances of tripping.

M. Gaiffe has devised apparatus used to light the chandeliers of the Paris National Assembly Hall. The hall is lighted by means of chandeliers containing 256 burners. To each chandelier a wire conducts the electric charge, but the return currents traverse a single cable to which all the wires converge. Each wire at the battery end—or rather induction coil end—starts from a separate insulated metallic button, which are put in communication with the secondary wire of the coil by means of an excitor terminated by a ball, and attached to the coil by a chain; the other end of the coil's secondary wire is is in connection with the return cable. The wire starts from the button and terminates at the burner; it resumes its course onward to the return cable, the circuit being complete, with the exception of a small breakage at each burner. To light the hall, the coil is first worked; then the gas is turned on, and the excitor applied to the several buttons causes sparks to be emitted at each burner, and thus enflames the escaping gas.

M. Charles Vavin has invented a magneto-mechanical sorter. Its object is to mechanically separate iron chippings and dust from the copper found mixed with the detritus and filings of factories. This sorting is ordinarily accomplished by hand. It takes up much time, and injures the workmens' health, on account of stooping all day over powdered materials containing copper. M. Vavin's apparatus consists of two hollow superposed cylinders revolving in the same direction, upon which the material to be sorted is spread by a hopper. The surface of these cylinders is formed by soft iron bands maintained in a continuous magnetic condition by magnets. To the surface of these cylinders then the iron particles attach themselves, and at a certain time they are detached by revolving brushes, and thrown into a side box, whilst the copper and earthy particles fall to the bottom of the apparatus. M. Mangon says he has used this apparatus to search for titanous iron in arable lands with such successful results as could never have been attained by any other means—chemical or otherwise.

The following interesting discovery, which is likely to be of considerable practical importance in telegraphy, was communicated by Mr. Edison to a recent number of the "Scientific American." The salient feature in Mr. Edison's discovery is the production of motion and of sound by the style of the Bain telegraphic instrument, without the intervention of a magnet and armature. By the motion thus produced, he works any of the ordinary forms of telegraph printing or sounding instruments, or relays, and is enabled to send messages, by direct tranmission over thousands of miles of wire, at the highest speed, without re-writing, delay, or difficulty of any kind. More than this, his apparatus operates in a highly effective manner, under the weakest electric currents, and he is able to receive and transmit messages by currents so weak that the ordinary magnetic instruments fail to operate, or even give an indication of the passage of electricity. Thus, when the common instruments stand still, owing to feebleness of current, the Edison telegraph will be at full work. The author has named his discovery the electro-motograph. The instrument attracted considerable notice at the recent *soiree* of the Society of Telegraph Engineers.

Dr. Ph. Carl has arranged a new tangent-electrometer for lectures, which unites very great sensibility with the advantage that the electric phenomena can be recognised at a great distance, and can be adapted for the execution of absolute measurements. The instrument is represented in the figure one-twelfth its size. Upon a wooden support A A, stands an insulating glass rod, B, which supports a brass fork, C, provided above with steel bearings. In



these lies the knife-edge of a short brass balance-beam, with which is connected a long index E. In the ends of the arms of the balance fine glass tubes (such as are used for vaccine lymph) are cemented, F F, covered with shellac varnish, and bearing at their ends the elder-pith balls, G G. Behind this balance there stands upon the same footboard, A A, a wooden support, H H, with the scale, J J. On the balance-arms is cut a screw-thread, by means of which the weights, K K—made in the form of female screws—can be set so as to bring the index E to the zero point of the scale. Below the balance-beam there is a weight, *z*, to regulate the distance from the centre of gravity to the fulcrum. It is concealed by the fork C, and is therefore represented in the figure by a dotted line. If vulcanite is very slightly rubbed upon fur, and approached to the elder balls, G G, even at a considerable distance, the maximum indication of E is obtained. The electrometer can be combined, in a very simple manner, with a condenser. In the wooded foot, L, the perpendicular glass rod, M, can be raised or lowered, and fixed at any height desired by means of the screw, N. The rod M terminates above in a vulcanite support, O, through which passes the brass wire, P, bent at right angle, and bearing at one end the small brass ball, Q, and at the other the horizontal copper disc, R, upon which the condenser plate, S, can be placed by means of the insulating glass handle, T. The plates R and S can be unscrewed and replaced by others, as may be requisite. In cases where no condenser is required the plate R may be removed, and a simple brass ball fixed in its stead. The apparatus is not merely an electroscope, but an electrometer. If the disc R is replaced by a brass ball connected with any source of electricity, the ball G will be repelled to an angle *a*, and the magnitude of the repelling force is then proportional to the tangent of the angle of deviation.

LIST OF PUBLICATIONS AND PERIODICALS RECEIVED FOR REVIEW.

Arithmetic in Theory and Practice. By J. Brook-Smith, M.A., LL.B. Second Edition. *Macmillan and Co.*

A Treatise upon Railway Signals and Accidents. By Archibald D. Dawnay, A.I.C.E. *E. and F. N. Spon.*

Synopsis of the Flora of Colorado. By Thomas C. Porter and John M. Coulter. *Trubner and Co.*

Results of Astronomical Observations made at the Melbourne Observatory in the Years 1869 and 1870, under the Direction of Robert L. J. Ellery. *Melbourne: Mason, Frith, and M'Cutcheon.*

An Experimental Enquiry into the Nutrition of Animal Tissues. By William Marcet, M.D., F.R.S. *Longmans and Co.*

The Transit of Venus. By George Forbes, B.A. *Macmillan and Co.*

Pharmacographia—a History of the Principal Drugs of Vegetable Origin met with in Great Britain and British India. By F. A. Flückiger, Ph.D., and Daniel Hanbury, F.R.S. *Macmillan and Co.*

Sun and Earth as Great Forces in Chemistry. By T. W. Hall, M.D. *Trubner and Co.*

Reliquiæ Aquitanicæ. Part XV. Edited by T. Rupert Jones, F.R.S. *Williams and Norgate.*

Brinkley's Astronomy. By J. W. Stubbs, D.D., and F. Brunnow, Ph.D. *Longmans and Co.*

The Protoplasmic Theory of Life. By John Drysdale, M.D., &c. *Bailliere, Tyndall, and Cox.*

Patents and Patentees. Vol. vii. Indexes for the year 1872. By W. H. Archer, Registrar General of Victoria. *Melbourne: John Ferres.*

Insects Abroad; being a Popular Account of Foreign Insects, their Structure, Habits, and Transformations. By the Rev. J. G. Wood, M.A., F.L.S. *Longmans and Co.*

Polarisation of Light. By William Spottiswoode, M.A., LL.D., F.R.S., &c. *Macmillan and Co.*

The Elements of Embryology. By M. Foster, M.A., LL.D., F.R.S., and F. M. Balfour, B.A. *Macmillan and Co.*

Popular Treatise on the Patent Laws. By John Brown. *E. and F. N. Spon.*

The Elements of the Psychology of Cognition. By Robert Jardine, B.D., D.Sc. *Macmillan and Co.*

An Elementary Exposition of the Doctrine of Energy. By D. D. Heath, M.A. *Longmans and Co.*

The Aërial World: a Popular Account of the Phenomena and Life of the Atmosphere. By G. Hartwig, M.D. *Longmans and Co.*

Transits of Venus: a Popular Account of Past and Coming Transits. By R. A. Proctor, B.A., &c. *Longmans and Co.*

Economic Geology, or Geology in its Relation to the Arts and Manufactures. By David Page, LL.D., F.G.S. *W. Blackwood and Sons.*

Evolution and the Origin of Life. By H. Charlton Bastian, M.A., M.D., F.R.S. *Macmillan and Co.*

The Doctrine of Descent and Darwinism. By Oscar Schmidt. *Henry S. King and Co.*

Elements of Animal Physiology. By John Angell. Enlarged Edition. *William Collins, Sons, and Co.*

Principles of Metal Mining. By J. H. Collins, F.G.S. *William Collins, Sons, and Co.*

Elements of Magnetism and Electricity. By John Angell. *William Collins, Sons, and Co.*

The Methods of Ethics. By Henry Sidgwick, M.A. *Macmillan and Co.*

Heredity: a Psychological Study of its Phenomena, Laws, Causes, and Consequences. By Th. Ribot. *Henry S. King and Co.*

The Origin of Civilisation and the Primitive Condition of Man. By Sir John Lubbock, Bart., M.P., F.R.S. *Longmans and Co.*

PERIODICALS.

Macmillan's Magazine.

Naval Science.

The Popular Science Review.

The Geological Magazine.

The American Chemist.

The Westminster Review.

PROCEEDINGS OF LEARNED SOCIETIES, &c.

Monthly Notices of the Royal Astronomical Society.

Monthly Microscopical Journal.

Proceedings of the Royal Society.

Transactions of the Manchester Geological Society, Vol. xiii., Part V.